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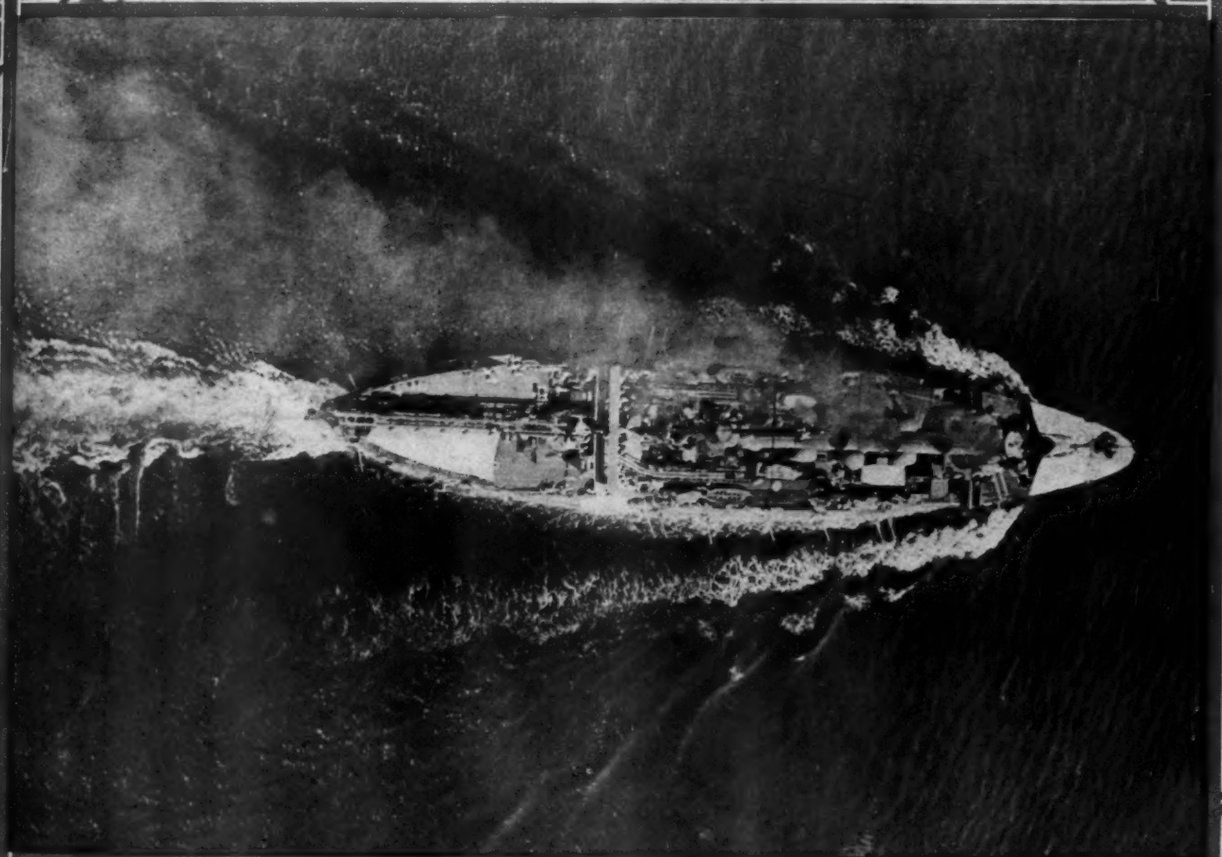

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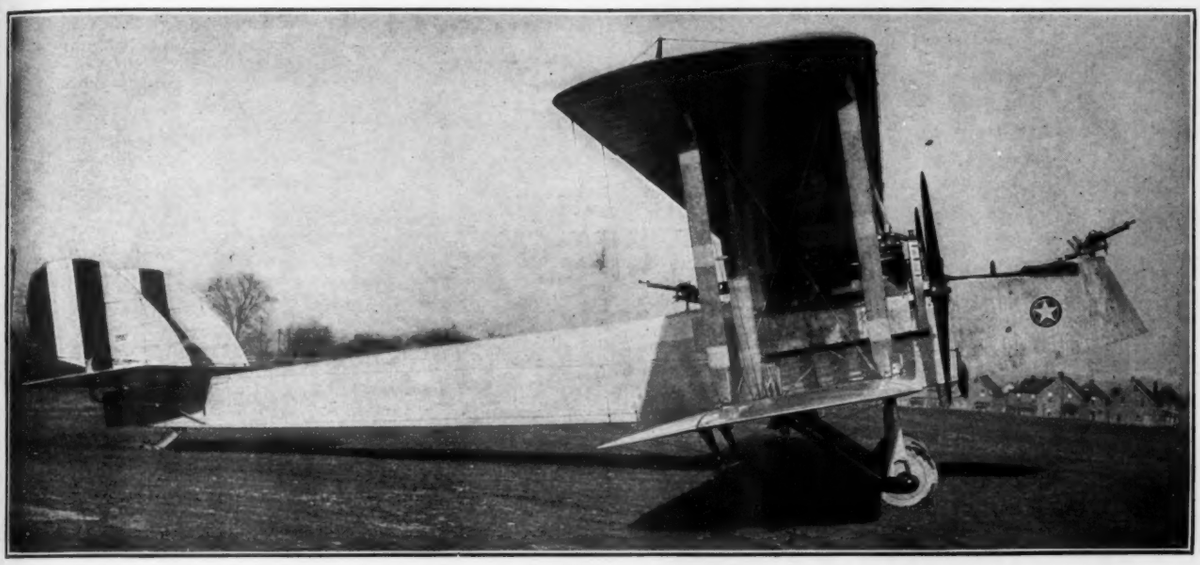

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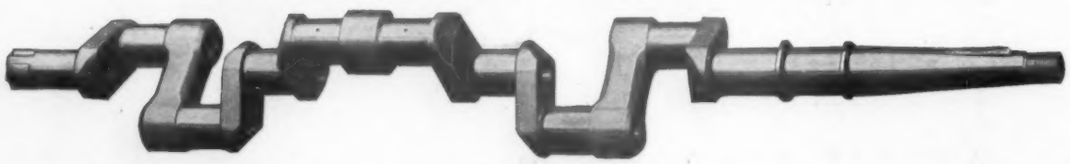

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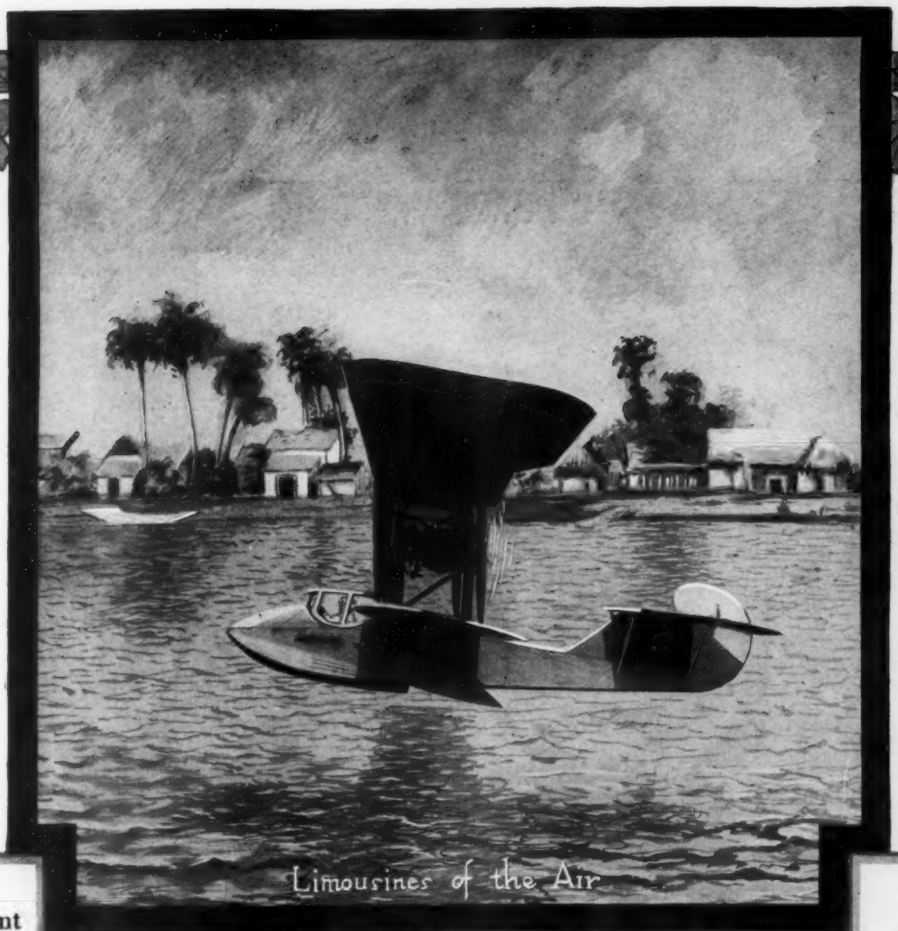

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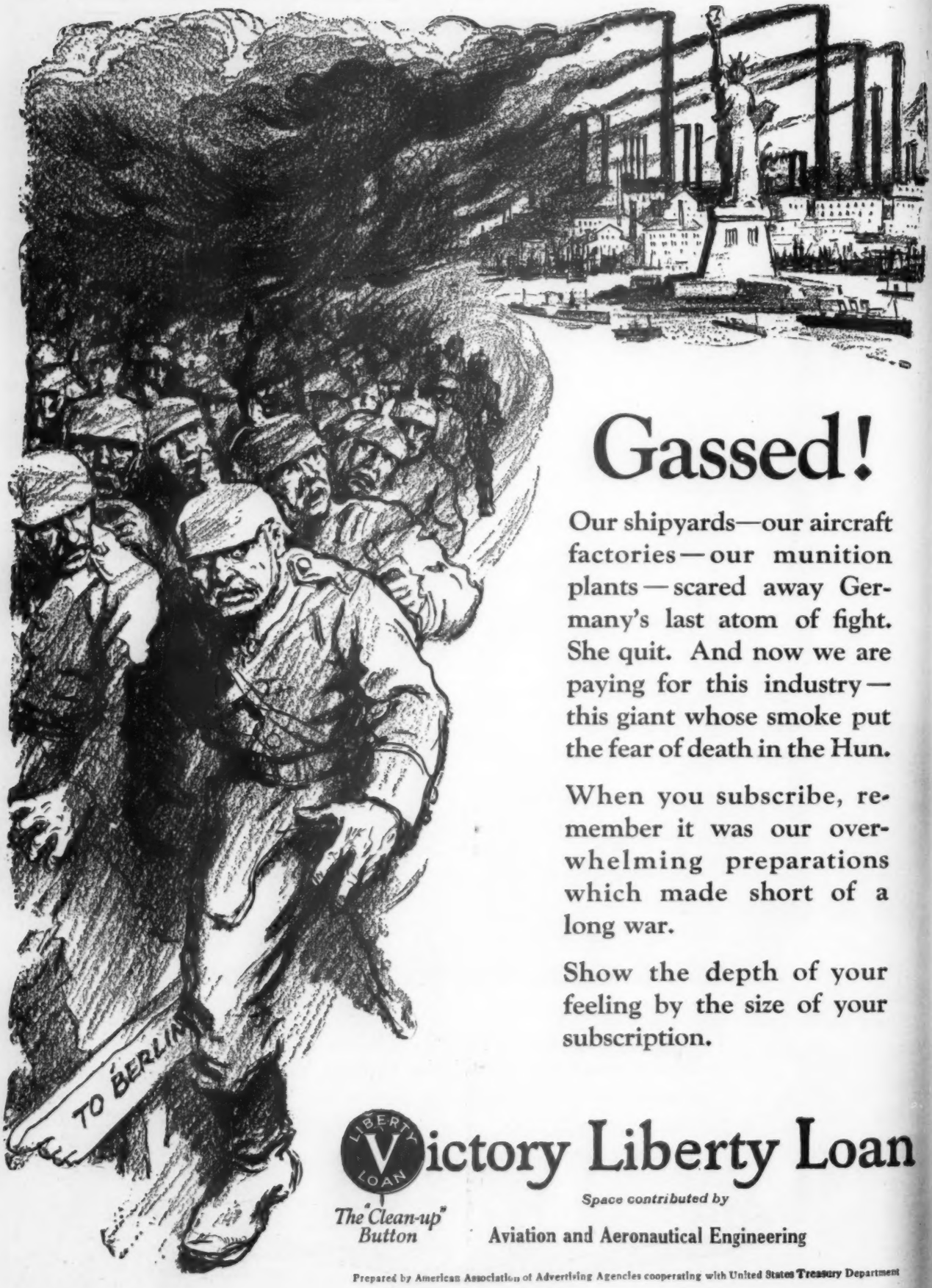

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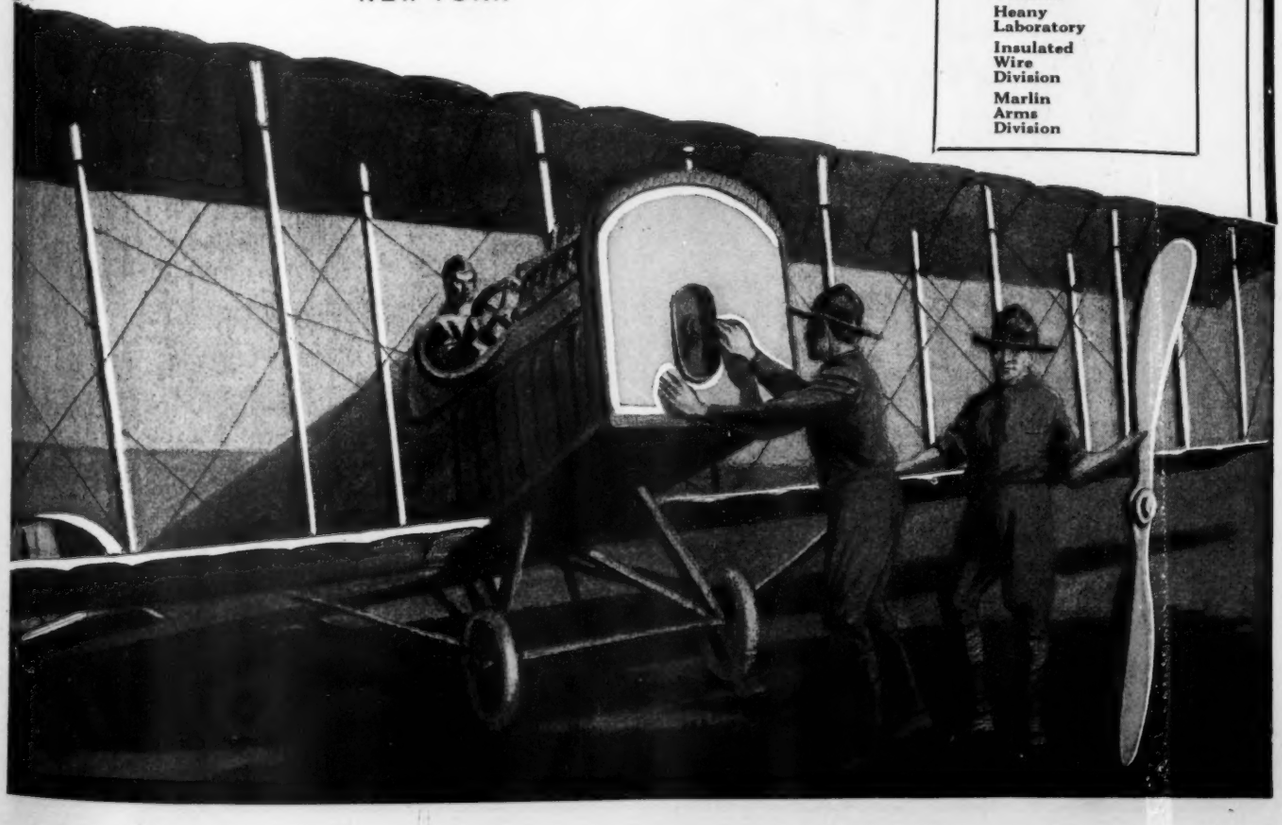

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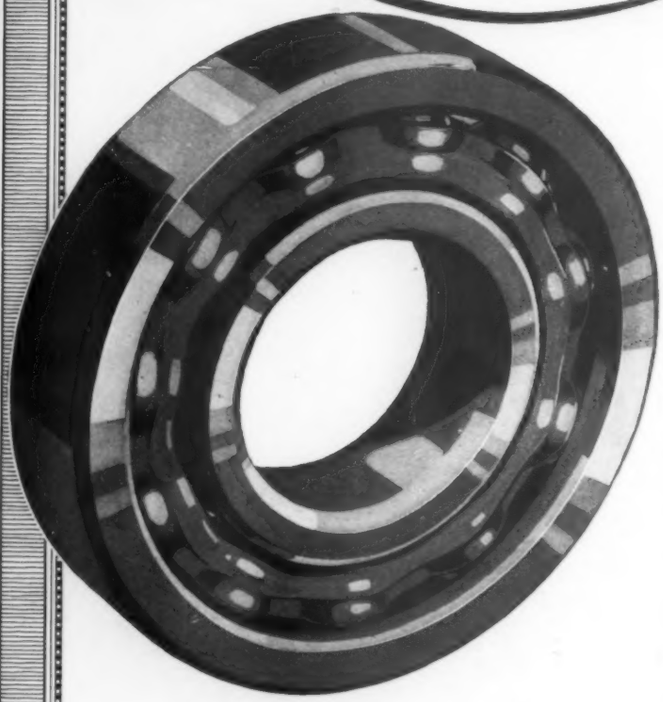

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Vol. VI | April 15, 1919 | No. 6

FIVE months have now elapsed since the signing of armistice brought the war to an end. The vast air forces which the Allies organized for the victorious termination of the war are now going through the process of demobilization and plans are being formulated for the establishment of aerial transport services which would utilize to best advantage the surplus of aeronautical personnel and material the general demobilization is creating.

That in the formulation of these plans coordination is imperative will not be disputed in view of the novel nature of the field aeronautics is to enter. Everything in this domain has to be determined empirically, from the most advantageous types of aircraft to rules of traffic, from aerial fares to insurance, from territorial rights to the organization of landing stations, and so forth.

The magnitude of this work can hardly be overrated and *per se* justifies the demand that it be carried out without friction, that is, in coordination. This requirement is naturally most satisfactorily answered where the government takes a hand in the matter and gives assistance to those concerned in their struggle with these much involved questions.

In Great Britain, with the demobilization of the Royal Air Force, General Sykes has been appointed Controller General of Civil Aviation, and will head in the Air Ministry a department entirely devoted to the control and development of commercial aeronautics.

The Royal Air Force estimates for 1919-20 provide a sum of $15,000,000 for civil aeronautics, two-thirds of which are to go to research and experiments while the remainder is to be employed for the maintenance of the new department and the development of transport aircraft.

In France, Colonel Leclerc, formerly O. C. the Aerial Defenses of Paris, has been appointed Director of Civil Aeronautics and is charged with the task of organizing the entire system of commercial aerial routes. In this work he will have the assistance of the Commission of Civil Aviation, which the French government created early in 1917. Colonel Leclerc has already perfected a preliminary project of linking up the principal towns of France by a system of aerial routes, with main stations situated every 150 miles or so, and marked for both day and night flying. In short, the French government intends to organize the whole aeronautical ground establishment, such as hangars, repair shops, stores and staffs, and leave the exploitation of the aerial routes to companies chartered to carry passengers, goods and mails. Thus does France stimulate the development of commercial aeronautics.

In view of the above it may be asked what are our own authorities doing to foster aerial transport? There is in existence, within the National Advisory Committee for Aeronautics, a sub-committee on civil aerial transport, which has for some time been engaged in formulating a report on the principal problems of civil aeronautics. The publication at an early date of this report will be awaited with considerable interest, not to say anxiety, by all concerned with the best interests of American aeronautics.

The Variable Pitch Propeller

Some recent tests have demonstrated that it is entirely practicable to construct a variable pitch propeller and that by its use both speed and climb may be appreciably increased. Yet at the same time the increase in efficiency has not been as great as commonly expected on theoretical grounds.

Engineers in discussing the variable pitch propeller have tacitly assumed that since the efficiency of the element of a propeller is largely dependent on its angle of incidence and the corresponding lift over drag ratio, by suitably varying the pitch the same angle of incidence could be maintained under all flight conditions and consequently the same efficiency.

Unfortunately the efficiency of an element is not solely dependent on the lift over drag ratio; it is dependent on the pitch angle also, which should be as large as possible for efficiency, and it is further dependent on the ratio of the velocity of the slip-stream to the velocity of the plane. The three quantities are connected in a complicated way and their relationships are at the very basis of our propeller theory.

Thus on a climb, no matter what is done to the pitch and to the angle of incidence of a blade element, the forward speed must diminish and the velocity of the slip stream increase with the thrust, which means a decrease in efficiency if even the same angle of incidence is maintained. It follows from this that the efficiency of a propeller under varying conditions is not entirely within the control of the variable pitch propeller. Where the main utility of the device lies, is that by making possible a smaller angle of attack, the engine can regain most of the r. p. m. it loses in a climb.

In spite of this, important improvements can be obtained. Thus with a JN-4H equipped with a 150 hp. engine, a gain in ceiling of 3000 feet was obtained. At 15,000 feet, with the variable pitch propeller, a speed of 88.2 m. p. h. was attained as compared with the 73 m. p. h. of the fixed propeller.

The Caproni E-3 Night Bomber

The Caproni E-3 night bomber is a three-engine biplane of considerable originality, which was developed during the war in Italy with the view to having a heavy load-carrying airplane in which the splitting of the power plant into three independent engine units would insure great reliability of operation. This type of Caproni bomber—there also exists a three-engine triplane of huge dimensions—has extensively been used on the Italian and French fronts for long-range night bombing, and though its general outline has hardly changed since it was introduced in the Italian air service in 1915, the power plant has undergone many alterations. At first Gnôme, Le Rhône, Renault and Salmson engines were used in various combinations, and it was only when the Fiat 260 hp. engine became available that the use of the latter became standard on the Caproni bomber's manufactured in Italy.

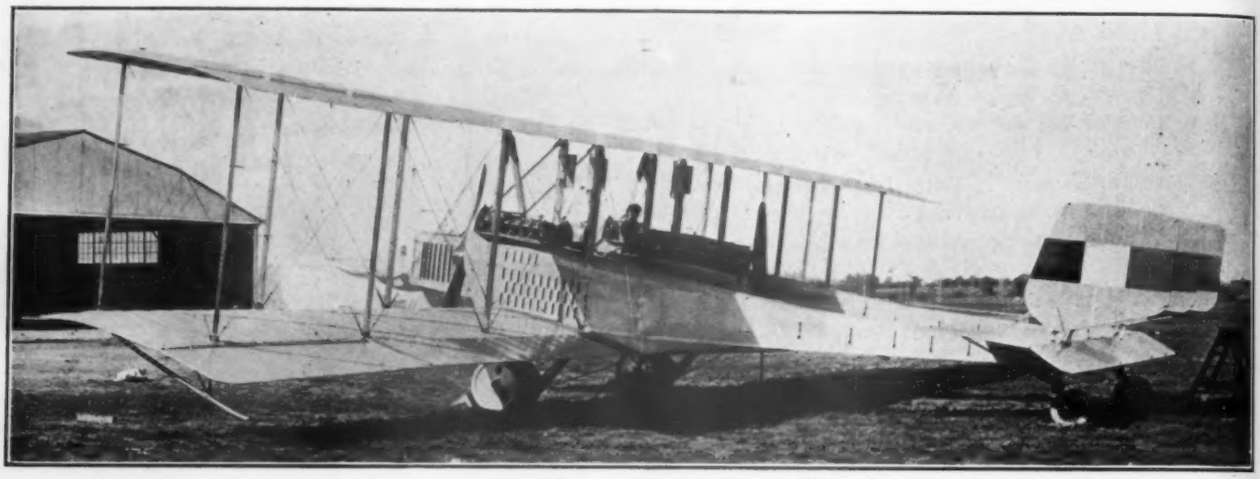


FIG. 1. THREE-QUARTER REAR VIEW OF THE CAPRONI E-3

The machine described and illustrated herewith, which was manufactured by the Standard Aircraft Corp., differs only in minor details from its Italian prototype, though its dimensions have been increased with respect to the latter in order to carry the heavier and more powerful Liberty-12 engines. These are of the low-compression, Navy type, and develop 330 hp. at 1590 r.p.m.; the fuel consumption is .55 lb. per hp. hr., the oil consumption .03 lb. per hp. hr.

The mounting of these engines constitutes the most outstanding feature of the Caproni bomber, for this arrangement is not met with in any other existing airplane; it may be described as follows: In the rear portion of a central nacelle, which affords accommodation to the crew of three and contains two control sets, instruments, bomb racks and gun mounts, is fitted a Liberty-12, driving a pusher airscrew; a fuel tank of 130 gal. capacity and an oil tank of 16½ gal. capacity are fitted in front of the engine, while the radiator is let into the nose of the nacelle. On either side of the nacelle there is a wing fuselage which carries a Liberty-12 with tractor airscrew and nose radiator, and contains fuel and oil tanks of the same capacity as those in the nacelle. These wing fuselages extend all the way back and serve to support the tail unit, as may be seen from the accompanying illustrations (Fig. 1).

Otherwise, from the engineering point of view, this machine does not invite particular comment; the general construction is of conventional design, though attention may be called to the lack of vertical fin surfaces abaft and the use of three balanced rudders which is a feature seldom met with nowadays.

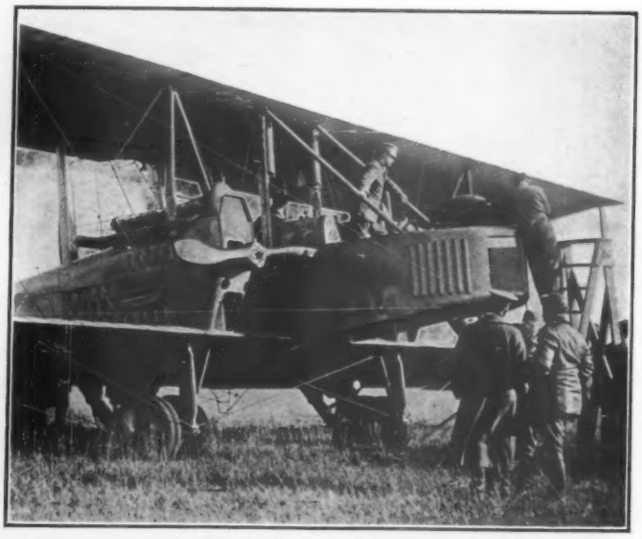


FIG. 2. FORE PART OF THE CAPRONI E-3

The gross, or flying, weight of the machine is 12,914 lb., and the total wing area 1384 sq. ft.; the wing loading is consequently 9.3 lb./sq. ft., and the power loading, with three Navy-type Liberty engines, 13 lb./hp. The ground speed is 100 m.p.h., and the climb, 6500 ft. in 16 min. 20 sec., and 10,000 ft. in 49 min.

The armament consists of two Lewis Guns, one of which is mounted on a gun-ring in the nose of the nacelle, while the other is carried behind the wings on a lightly built skeleton turret (Fig. 2), which affords the after gunner a very wide arc of fire, covering virtually every angle. In addition to this defensive armament, six 230-lb. and four 110-lb. bombs are carried in racks in the nacelle for offensive work.

The main constructional features of the Caproni E-3 night bomber are given herewith, together with a tabulation of dimensions and weights.

Main Planes

Main planes are in five sections, each respective section, top and bottom, being of the same length. Camber of under curve of wing section is 3.267 in., and the maximum ordinate occurs 31.496 in. back from the leading edge; camber of upper curve is 7.618 in. and maximum ordinate is 39.37 in. from leading edge. The greatest thickness of rib is 4.665 in. and occurs 55.118 in. from leading edge. The angle of incidence of top plane is 5 ft. 30 in., of bottom plane 6 ft.; the gap is 9 ft. 26 in.

All interplane wing struts, except the four large ash struts paralleling vertical sides of fuselage and the four central struts from main longitudinal members of nacelle to plane, are of stream-line section steel tubing when available, or of round steel tubes and stream-line fairing of spruce. The four short

central struts running from nacelle to upper plane are all of spruce and tube construction, and the next struts out on the other side are of two laminate ash.

All struts sockets are of the same general design, but not tinct lips protruding above spar. All are drilled. The center lips receive the strut, which is secured with a bolt passing fore and aft through all; the two outside lips have a bolt passed through which receives the turnbuckles and cable ends of inter-

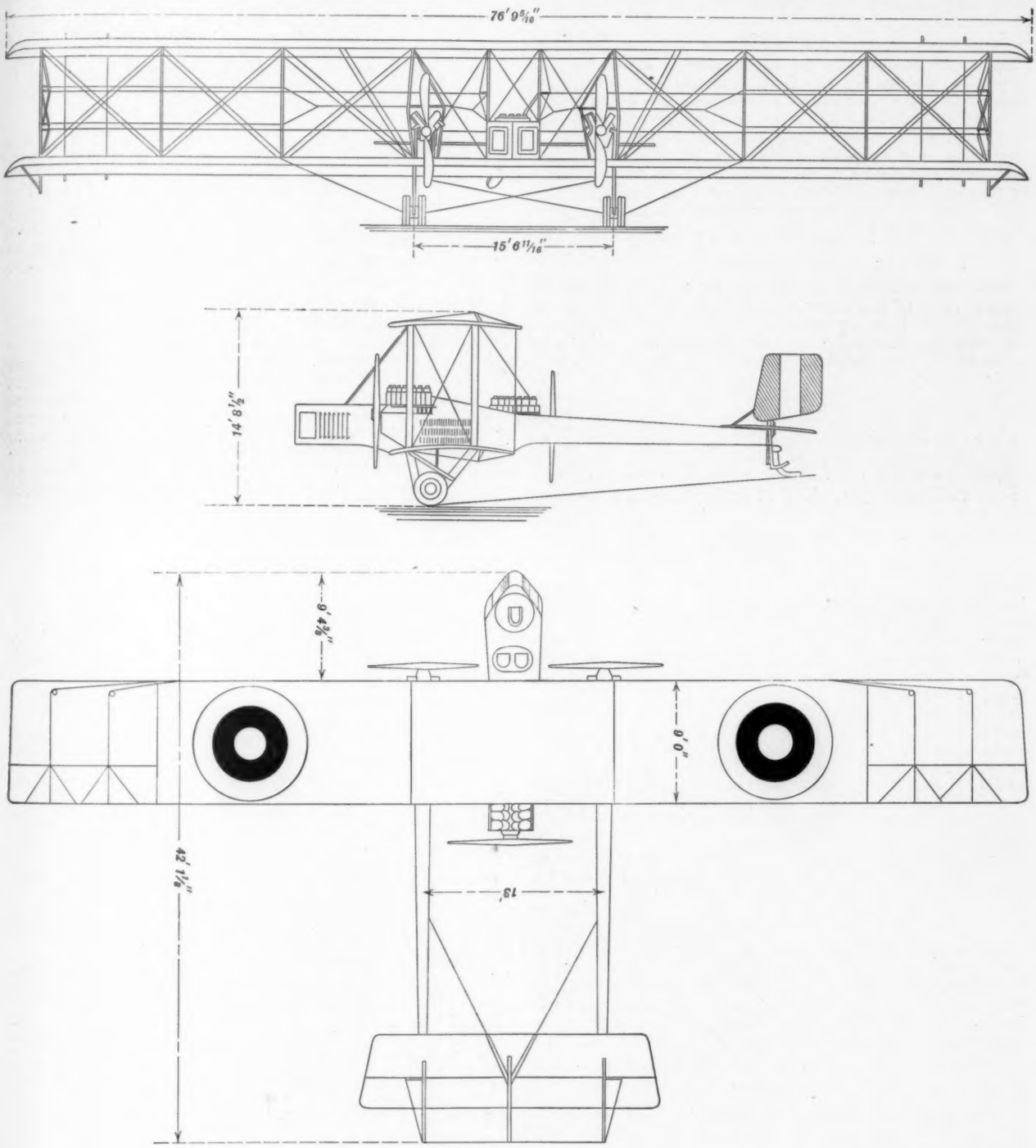


FIG. 3. OUTLINE DRAWINGS

interchangeable, due to the fact that those parts coming closer to the center of the machine and receiving greater stresses are built heavier. This is also true of the struts, whose cross section decreases as the wing tips are reached. The strut sockets consist of two steel plates welded to the fore and aft sides of a square steel sleeve, which in turn is slipped over the outside ends of the spars, secured thereto with three ¼-in. bolts; the next adjoining sections have their spars slipped into this socket. The two plates forming strut sockets have three dis-

plane wiring. The bolt passing through strut ends also serves as an anchorage for all incidence wires.

The two central sections are 16 ft. 1.38 in. long, intermediate 18 ft. 53 in., and outer sections 11 ft. 10 in. All main plane spars are 1 19/32 in. x 3⅝ in., the greatest depth, of course, being in the vertical plane. Central section and upper intermediate section spars are of ash, all others Douglas fir or spruce. All spars are built up of two laminations, whose innermost sides have been channeled for lightness.

Ailerons

The ailerons are 12 ft. 2¾ in. long at the trailing edge, 3 ft. 2¾ in. wide at the outer end, and 2 ft. 10 in. wide at the inner end. They have two horns each, and top and bottom ailerons are interconnected by two 3/32 in. cables provided with turnbuckles.

Truss System

There are nine bays in the entire inter-plane trussing. All incidence wire are No. 10 steel-wire, except in center section, where they are 5/32 in. cable. All turnbuckles are at bottom of struts and are received directly by socket terminals. Where wires and cables cross, a small brass disk is placed between; four small holes pierce this disk through which wire lacing sustains same in place. Two drift wires run from those of nacelle to tops and bottoms of first struts out from fuselage. Four drift cables run from rear end of these members to tops of center and next adjoining struts.

Flying Position

When the machine is in true horizontal flying position the vertical sides of spars are in true vertical position. A true horizontal line bisecting rear spar is just 5.748 in. distant from a parallel line bisecting front spar when the lower plane has an angle of 6 deg. Incidence is corrected to this measure when setting up.

Fuselage

The two fuselages are built up of four ash longerons 13/16 in. x 13/16 in., which are channeled on the vertical sides, between strut sockets, from the fifth bay to the tail post. The splices, one on the top members and two on the lower ones, are of the lapped type, about 12 in. long, glued and secured with two countersunk wood screws: the entire joint is securely wrapped with 1¼ in. cloth tape laid on with glue. Engine beds are 1 15/16 in. x 4¼ in. x 9 ft. 10⅞ in.

The first two vertical struts forward on either side of fuselage are 1 3/16 in. round steel tubes; the lateral struts at joints where the tube struts join the lower longerons are of ash; all other struts are of spruce. Tail post is of steel tube. All trussing is of steel wire. In all there are twelve trussed bays in bottom and sides, and ten in top of fuselage. The greatest depth of fuselage is 30¾ in. and occurs about 8 ft. 3 in. from front of engine beds.

The streamline turtle back is built up of spruce strips secured to walnut arches with small screws. The fuselages are secured to the lower wing spars by two U bolts passing over tops of bottom lateral struts, down over spars and through steel fish plates on under side of spar. The covering from the tail post to a point on the fuselage flush with rear spar of main planes is of cloth. From this point backward to trailing edge of main planes a ⅛ in. walnut veneer covers top; from rear spars forward to front spars aluminum sheets with cooling louvres enclose sides. Radiator is mounted just below and in front of propeller shaft with special brackets.

Undercarriage

The undercarriage consists of two U-shaped laminated wood struts which carry eight wheels arranged in twin sets on two axles with radius rods. The wheels are rubber-sprung. The U-struts, of streamline section, are built up of ash and spruce laminations, and are wrapped with heavy linen tape laid on with glue and varnished. The axles are 1 15/16 in. dia., 5/32 in. wall steel tubes, 32 in. long.

Empennage

The empennage consists of three balanced rudders, a horizontal stabilizer provided with positive incidence-change gear, and a one-piece hinged elevator. Rudders are of composite steel tube and spruce construction; the stabilizer is built up of steel tubing and sheet steel ribs, while the elevator is entirely constructed of steel tubing.

The three rudders are held in place by means of steel posts, trussed to one another by wires; the two outer rudder posts are slipped into the fuselage tail posts, while the central rudder post is secured to a socket brazed to the rear spar of the horizontal stabilizer. Only the outer rudders have rocker arms.

The stabilizer is secured to the fuselages by means of steel tubes faired with laminated spruce. Two such struts extend from the bottom of each tail post outward to the front and rear spars of the stabilizer, and two extend inward to the bottom of the front and rear spars. Two like struts extend from a point on the central rudder post, about half way up rudder, to the points on the front stabilizer spar where the struts from the tail post meet.

Nacelle

The nacelle is built about two longitudinals of laminated spruce with an elaborate rib structure which gives the proper stream line contour, and is covered with 5/32 in. three-ply. It is secured to the lower wing spars by four struts set at a slight angle outward; four more struts fix the nacelle to the upper wing. The overall length of the nacelle is 19 ft. 10 in., the greatest depth, 5 ft. 6 in.

Instruments

Three tachometers and one gas pressure gage are located on the dashboard. A thermometer for registering the temperature of the center engine is at the pilot's left, and two thermometers for the lateral cooling systems are located on the top of the reserve tanks. An air speed indicator is mounted at the pilot's left.

Lighting System

Three 200 C. P. searchlights are located, one on each side of the nacelle and one on the nose. The forward light is for signalling only, and cannot be used while the two side lights are burning. On 2 C. P. light is located on each side of the cockpit, one on each lower wing tip, and one on each side, but some distance from the nacelle, on brackets. A 12-volt, 50-ampere storage battery, for operating the lights, is mounted in the nacelle at the side of the engine.

Weight Schedule

	Pounds
Power Plant	
Motors complete with carburetor and ignition system (3)	2436
Radiators (3)	360
Radiator and engine water	450
Fuel tanks empty in fuselages (2 sets)	252
Fuel tanks empty in nacelle	126
Oil tanks empty in fuselages (2 sets)	60
Oil tanks empty in nacelle	19
Gas primer tanks (2)	28
Exhaust manifolds (3 sets)	60
Propeller and hubs (3 sets)	150
Gas and water piping in nacelle	250
Cowling (3 sets)	180
Starters (3)	75
Total	4446
Fuel and Oil	
Fuel (390 gal.)	2350
Oil (50 gal.)	350
Total	2700
Passengers and Miscellaneous	
Crew	553
Dashboard Instruments	50
Total	603
Armament	
Gun mount and turret.	
Total	78
Bombing Equipment	
Bombs.	
Total	1873
Reconnaissance Instruments	
Photographic Instruments.	
Total	92
Nacelle and Fuselages	
Nacelle frame	508
Nacelle controls	50
Fuselage frames (2)	288
Fuselage controls (2)	74
Tail skids (2)	18
Total	938
Tail Surfaces with Bracing	
Stabilizer 77.7 sq. ft.	70
Elevator 51 sq. ft.	41.5
Fins—none	...
Rudders (3)	100
Stabilizer brace tubes	8.5
Total	220.0
Wing Structure	Pounds
Upper wing with fittings	563
Lower wing with fittings	570
Interplane Struts	293
Interplane Cables	101
Ailerons (4)	104
Total	1631
Undercarriage	
Weight of wheels and tires complete	160
Weight of axle shock absorber, etc.	190
Total	350

SUMMATION OF WEIGHTS

	Weight (lb.)	Percentage of Gross Weight
Power plant	4446	34.4
Fuel and oil	2700	20.9
Passengers and miscellaneous equipment	603	4.6
Armament	78	.6
Bombing equipment	1873	14.5
Reconnaissance instruments	92	.7
Nacelle and fuselages	938	7.3
Tail surfaces with bracing	220	1.7
Wing structure	1631	12.6
Undercarriage	350	2.7
	12931	100.0

Structural Characteristics

MAIN DIMENSIONS

Overall length, 41 ft. 3 11/16 in.
Overall height, 14 ft. 8½ in.
Wing section, Eiffel 36 modified.
Area of upper wings with ailerons, 692 sq. ft.
Area of lower wings with ailerons, 692 sq. ft.
Total wing area, including ailerons, 1384 sq. ft
Span, upper wing, 76 ft. 9 5/16 in.
Chord, upper wing, 9 ft. 1¾ in.
Aspect ratio, upper wing, 8.22.
Span, lower wing, 76 ft. 9 5/16 in.
Chord, lower wing, 9 ft. 1¾ in.
Aspect ratio, lower wing, 8.22.
Gap, 9 ft. ¼ in.
Gap/Chord, .962.
Stagger, none.
Angle of lower wing chord to propeller axis, 5 deg.
Height of axis of propeller above ground with: (1) Machine resting on ground, 5.25 ft. approximately; (2) Propeller axis in line of flight, 6.13 ft. approximately.
Angle between line from base of wheel to C. G. with a vertical line when machine is horizontal.
Angle between line joining wheel base and skid to a horizontal line, 5 deg.
Stabilizer setting to lower wing chord, zero approximately.
Aileron area upper wings (2), 40 sq. ft. each, unbalanced.
Aileron area lower wings (2), 40 sq. ft. each, unbalanced.
Area of stabilizer, 77.7 sq. ft.
Area of elevator, 51 sq. ft., unbalanced.
Area of rudders (3), 17.5 sq. ft. each, balanced.
Length from tail post to center of gravity, 25 ft. approximately.

Significance of Oxygen in Balloon Gas

By Junius David Edwards and Paul G. Ledig

Bureau of Standards, Washington, D. C.

In the rapid progress of lighter-than-air craft, which is widely prophesied for the near future, the development of fabrics for the envelope which are more nearly impervious to gas, should play a prominent part. A perfectly gas-tight fabric has not yet been realized in practice. The problem of gas leakage, though not so pressing in the case of kite balloons, is of great importance in the case of airships, where large capacity and the necessity of insuring continuity of service, make it desirable to conserve the filling gas as long as possible.

There are two phases to this problem; first, the loss of hydrogen by leakage outwards, and second, contamination of the gas in the balloon by air passing inward. The loss of hydrogen is not so serious because the hydrogen can be easily replaced. The contamination of the gas in the balloon by air, however, is progressive and eventually reaches such a stage that the balloon must be deflated and refilled with "pure gas."

Leakage from a balloon may take place in two characteristic ways. If there are any openings in the balloon, large or small, gas will leak out so long as the pressure on the inside is higher than that outside. Such openings may occur around valves, fittings, patches, at pin holes, and wherever there are stitches which are imperfectly protected with tape. Gases also penetrate the rubber coatings of a balloon fabric in the absence of even microscopic holes by the process of dissolving in the rubber and evaporating, so to speak, from the opposite side. This permeability to gases is an intrinsic property of rubber and can only be modified, not eliminated, by the method of manufacture of the rubber coatings. Because of the solubility of hydrogen in rubber, the best of the modern airship fabrics seldom have a permeability of less than 8 liters per square meter per 24 hours (measured at 25 deg. Cent.).

The permeability of a rubber film to any gas is about proportional to the difference in partial pressures of that gas on the two sides of the rubber film. When the envelope of a balloon is freshly inflated the partial pressure of air inside the balloon is only 1 or 2 per cent, as against 100 per cent outside, and consequently the air penetrates into the balloon at a rate which is practically independent of the excess pressure existing inside the envelope. The rate at which it penetrates will of course decrease as the amount of air inside increases, because the difference in partial pressures decreases correspondingly. It should be noted that the relative rates of penetration of rubber by hydrogen and air are not the same, but have a ratio of approximately 4 to 1; that is, when the envelope contains approximately pure hydrogen, one volume of air passes through the fabric into the balloon for each four volumes of hydrogen leaking out.

The "air" that passes into the balloon differs in composition, however, from normal air. This is due to the fact that rubber is about twice as permeable to oxygen as to nitrogen. Thomas Graham,* for example, found that oxygen penetrated rubber about 2.5 times as fast as nitrogen does. As a consequence the "air" becomes richer in oxygen after diffusion through rubber; Graham found in some experiments that there was as much as 41.6 per cent oxygen in air which had diffused through rubber.

We have examined this point, using for the purpose a bag made from two-ply envelope fabric of a construction in common use. This was inflated with hydrogen (99.5 per cent hydrogen, 0.4 per cent nitrogen, 0.1 per cent oxygen), and the gas analyzed at regular intervals thereafter. It was found that after making corrections for the normal air originally present in the hydrogen (see above analysis), the "air" which penetrated the fabric contained a maximum of 41 per cent oxygen. The percentage of oxygen decreased gradually; equilibrium would be reached eventually when the gas inside the balloon had the same composition and partial pressure as the air outside. These experiments as well as others have shown that the gas other than hydrogen present in a balloon may contain a maximum of about 40 per cent oxygen. In any given case a lower percentage may be found, depending upon the amount of normal air present in the original gas and the amount of "air" which has since diffused in.

Aside from presenting an interesting phenomenon the foregoing facts have a very important bearing on the determination of the purity of balloon gas. One method which has been used in such testing is to determine the oxygen content of the gas by means of absorption with potassium pyrogallate in an Orsatt or similar gas analysis apparatus. In calculating the purity it is assumed that nitrogen is present with the oxygen in the proportions in which it occurs in air and that the residue is hydrogen. This method can never give the correct result because the fundamental assumption regarding the oxygen-nitrogen ratio is incorrect.

The specific gravity of hydrogen is a very delicate criterion of its purity, and is also a direct measure of its lifting power. Furthermore, the calculation of the purity of the hydrogen from its specific gravity is but little affected by changes in the oxygen-nitrogen ratio, because of the small difference in density of these two gases. For example, if the gas from a certain envelope had a specific gravity (dry) of 0.1628, its purity (percentage of hydrogen) would be 90 per cent, assuming the gas to be a mixture of hydrogen and air. If it were a mixture of hydrogen with a residue containing 40 per cent oxygen and 60 per cent nitrogen, as would be more likely, its purity would be 90.2 per cent. This difference would not be significant for most purposes.

It is obvious that the purity calculated in the usual way from the oxygen determination will be too low. This is strikingly illustrated by several examples taken from actual practice in the field. The oxygen was determined by absorption in the manner already indicated and the specific gravity was determined with a specific gravity apparatus of the effusion type, as designed by the Bureau of Standards especially for testing balloon gas. In one case which was brought to our attention the gas from an airship envelope contained 2.2 per cent oxygen and had a specific gravity (dry) of 0.1206. Its purity, as given by the two methods, was 89 and 94.5 per cent, respec-

* Phil. Mag., 32, p. 401; 1866.

tively. Accepting the latter figure as substantially correct, a simple calculation shows that the "air" in the envelope contained 40 per cent oxygen.

In another case the purity calculated from the oxygen determination was 80 per cent, and the specific gravity showed the presence of 86 per cent hydrogen. These figures indicate an oxygen content of 30.0 per cent in the "air" in the balloon. It is clear, therefore, that the determination of the oxygen content alone will not suffice for calculating the purity of the hydrogen. The specific gravity gives more reliable data for this purpose. The determination of oxygen may be useful, however, from another standpoint. It would be unsafe to handle a balloon filled with an explosive mixture even if the gas still had a useful lift. Because of the increase in the oxygen content, the explosive limits of the mixture are reached sooner than if the hydrogen were contaminated with normal air.

The data given in the literature dealing with the explosive limits of hydrogen and air and hydrogen and oxygen are somewhat contradictory and confusing. This is in part due to the fact that the explosive limit may vary with the existing conditions such as temperature of gas and point of ignition. The explosive limits of a gas are usually defined as the minimum and maximum percentages of the combustible gas with air or with oxygen which will propagate a flame indefinitely in any direction from any point of ignition. Because of the convection of heat upwards, a flame will be propagated more easily from the bottom of a balloon upwards than from the top down. The upper limit of hydrogen with air is variously given as 65 to 75 per cent; the upper limit of hydrogen with oxygen is given as approximately 95 per cent. Looking at the question from another angle, the explosive limit of oxygen in hydrogen is about 5 per cent; for the present purpose this limit can be considered to be not greatly changed by the probable variation of the amount of nitrogen present.

If a mixture of 80 per cent hydrogen and 20 per cent normal air is safe to handle, a mixture in a balloon where the "air" contained 35 per cent oxygen would be on the border line of safety when the purity of the hydrogen sank to 85 per cent, because it would then contain 5 per cent oxygen. Where it is the practice to discard the hydrogen when its purity has reached 85 per cent, it should be appreciated that the gas is potentially an explosive mixture and the utmost caution should be used in its handling.

Flexible Tubing

All commercial flexible tubing is rolled from strip metal, and turned over in passing through dies so as to make an interlocking joint.

The flexibility in ordinary full or semi-interlocked tubing is obtained from the sliding action of the joint parts, one on the other, within the joint, the coil remaining rigid.

The flexing in Titeflex tubing, as distinguished from that in interlocked tubing, takes place within annular diaphragms which are substantially at right angles to the axis of the tube and formed by the sides of U-shaped convolutions. The interlocking portions comprising the seam are compressed under heavy pressure to make a continuous, tight cold-welded structure. The flexibility is thus entirely within the metal and the seam is primarily self-tight.

The joints or seams of interlocked tubing are not inherently tight and to meet pressure conditions must be packed with a soft chord of asbestos, cotton, or rubber composition. This packing is the sole reliance for tightness, but it rapidly disintegrates under the action of gasoline with the result that it contaminates the fuel and eventually stops its flow. Where an outside casing is used, this soon becomes permeated by the fuel and involves beyond the loss of fluid also fire risk.

The superiority of Titeflex tubing over either construction and over wire-wound rubber hose consists in that it is permanently self-tight, free from internal rubbing action, and devoid of organic material that may become detached and contaminate the fuel. It bends freely and instead of retaining a set tends of its own accord to return to normal position when released. This springiness absorbs the vibrations unavoidable with some installations, like those of aircraft engines, and contitutes thus a valuable feature.

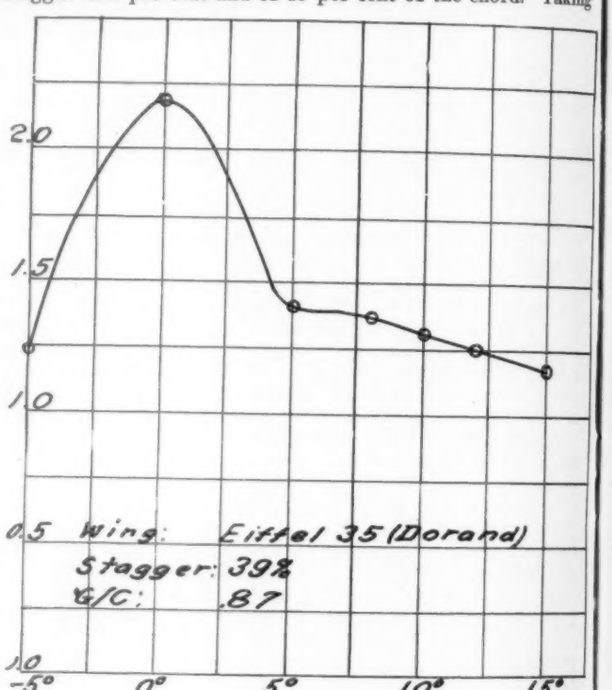
Titeflex tubing remains unaffected by low temperatures which would render any usable form of packing brittle; tests have shown that the contents of a Titeflex tube may freeze into solid without bursting the metal. In another test a 1 5/16 in. brass Titeflex tube was put under 120 lb. air pressure, sealed at both ends and permanently connected to a pressure gage. At a temperature of 70 deg. no change in the pressure reading of the gage could be detected during the period of the test, which lasted one year. Its resistance to crushing was demonstrated on a 10-in. length of ¾ in. tubing which was used as a roller between two iron plates, the upper one of which was loaded with 2,050 lb. of steel, without any permanent distortion resulting therefrom.

An important feature of Titeflex is that, should it be accidentally crushed, it can readily be repaired by soldering or brazing.

Load Distribution and Stagger

By Clarence D. Hanscom

The accompanying chart is derived from Eiffel's experiments with wing section No. 35 as used on the Dorand biplane. The tests were carried out using a gap-chord ratio of .87 and a stagger of 0 per cent and of 39 per cent of the chord. Taking



Correction for Stagger Effect on Wing Loading Ratio

the orthogonal biplane gross load distribution as a unit base for each angle, the increase in the ratio due to stagger was calculated in the form of a second ratio having a denominator of 1. This second fraction is the one plotted on the chart.

The curve was prepared with the idea that it would serve to indicate, in a very rough way, what effect a fairly large stagger might be expected to have on the load distribution ratios of other biplane arrangements. In application, the relation of the gross load on the upper wing to that on the lower is first found for the orthogonal cell at the given angle (e.g., 11/9 is a common figure). This fraction is then multiplied by the value on the curve corresponding to the given angle. The product of these ratios indicates roughly what distribution might be expected between the upper and lower planes.

The accuracy of this method is obviously open to question. Further tests will be necessary to show what percentage of error is involved in applying this special case generally. Flattening the lower camber should decrease the value of the ratio. Allowance should be made for any increase of gap from that of the tests, since the interference would decrease rapidly. The effect of a change of stagger would also have to be estimated. It seems probable, however, that if used with care the curve will not cause errors greater than those in other frequently used formulae and charts.

Course in Aerodynamics and Airplane Design

Part III.—Experimental Aeronautical Engineering

By Alexander Klemin

Technical Editor, Aviation and Aeronautical Engineering; Consulting Engineer, Aerial Mail Service; Consulting Aeronautical Engineer

Section 2. Testing of Control Surfaces

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Discussion of Theoretical Principles.—The testing of control surfaces is an easy matter from the point of view of the physical testing, but it is an extremely difficult one from the point of view of determining what loads the surfaces should actually be capable of withstanding.

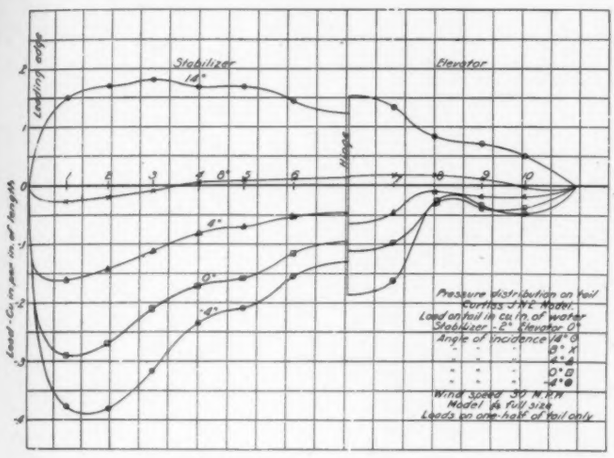


FIG. 1

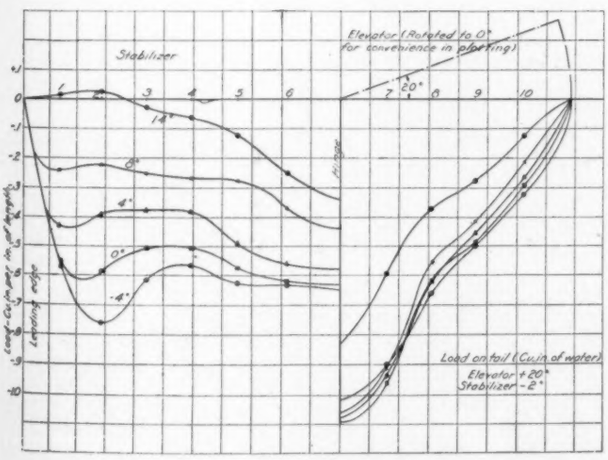

Stabilizer
Elevator (Rotated to 0° for convenience in plotting)
Hinge
Load - Cu. in. per in. of length
Load on tail (Cu. in. of water)
Elevator +20°
Stabilizer -2°

FIG. 2

In dealing with the horizontal tail surfaces, it is customary to consider that the maximum load on the elevator will be determined by the pilot's strength. This may, however, be quite unfair in the case of a small machine, where the tail surface load at maximum speed and maximum K_y will never be equal to the pilot's strength.

Sometimes a reverse procedure is taken, and tail loads computed from considerations of maximum speed and maximum K_y. This may be unfair to the large ship where the pilot's strength is quite inadequate to produce the necessary displacement of the elevators.

The subject thus bristles with difficulties.

Probably the most pertinent aerodynamical data on the testing of control surfaces is that obtained at the Massachusetts Institute of Technology under the direction of the Research Department at McCook Field. Tests were conducted on the Curtiss JN-2, with the stabilizer set at —2 degrees to the wings, with the elevator set at 0 degrees, 10 degrees up and 20 degrees up to the stabilizer, and at five angles of incidence for the wings, —4 degrees, 0 degrees, 4 degrees, 8 degrees and 14 degrees for each elevator position. The results of these experiments are summarized in the curves shown in Figs. 1, 2 and 3.

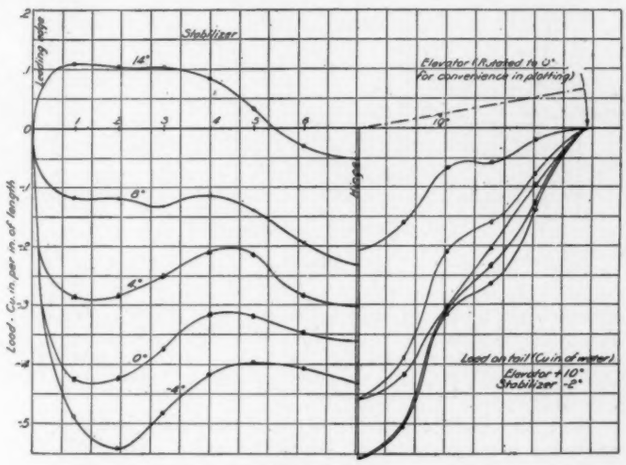

Stabilizer
Elevator (Rotated to 0° for convenience in plotting)
Hinge
Load - Cu. in. per in. of length
Load on tail (Cu. in. of water)
Elevator +10°
Stabilizer -2°

FIG. 3

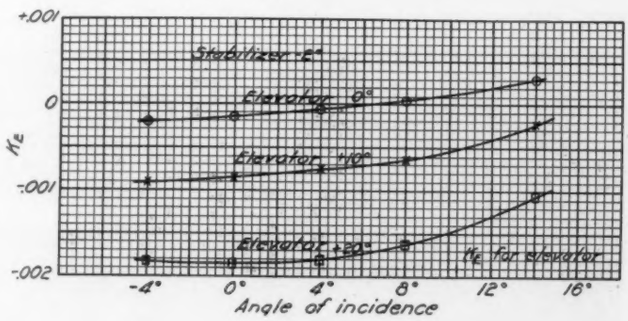


FIG. 4

From these curves a number of very valuable conclusions can be drawn.

(a) The current method of loading the elevator so that the load varies from zero at the trailing edge to a maximum at the leading edge is seen to be perfectly justified.

(b) The pressure distribution on the stabilizer is by no means uniform, and there is a definite region of maximum pressure at about ⅓ of the chord from the leading edge, and in sand-testing an allowance should be made for this.

(c) For small displacements of the elevator relative to the stabilizer, the mean loading on the elevator would appear to be much smaller than the mean loading on the stabilizer. For the larger displacement of the elevators, 20 degrees, as in Fig. 2, the maximum loading at the leading edge of elevator is much larger than the mean loading on the stabilizer, and the mean loading over the elevator is about equal to the mean loading over the stabilizer.

It would seem from this as if there should be a differentiation between the methods employed in sand loading the tail surfaces of a small machine and in loading the tail surfaces of a large machine. For the small machine it will be possible to turn up the elevators to a much higher angle, and impose on

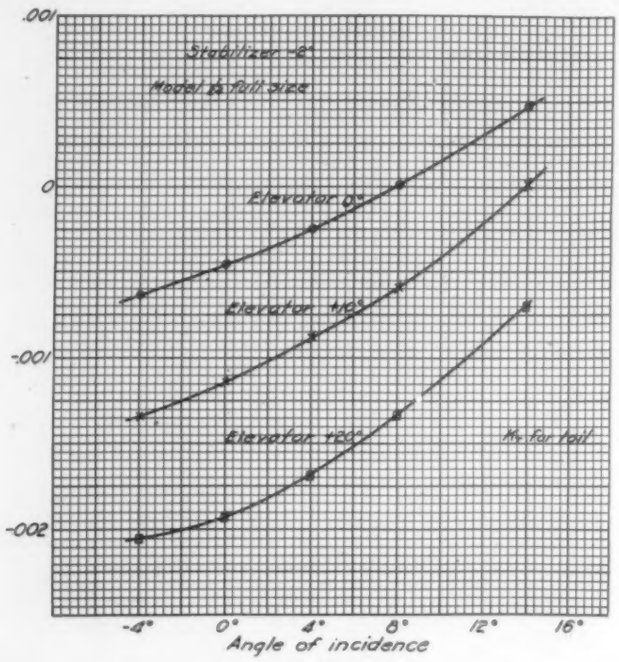


FIG. 5

them a mean load greater than that on the stabilizer. While on the large machine the pilot will not need, or be able, to displace the elevators to as high an angle, with the result that the mean loading on the stabilizer should be higher than that on the elevator.

With the little experimental data available, however, the question remains one of judgment alone. The following method is set down in tentative fashion:

(1) Assume a maximum pull of 150 lb. on the control stick (this is a value justified by experiment).

from a maximum at the leading edge to zero at the trailing edge, so that the center of pressure is at ⅓ of the chord, find the mean loading per square foot on the elevator which the pilot could exercise.

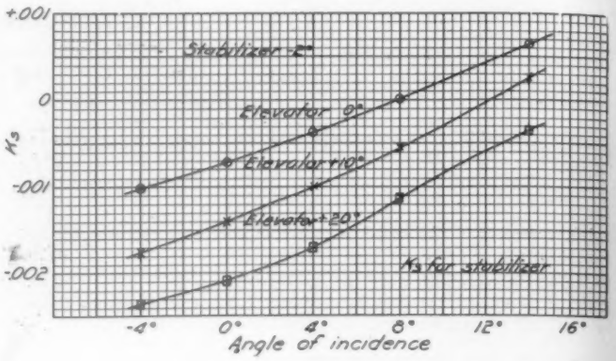


FIG. 6

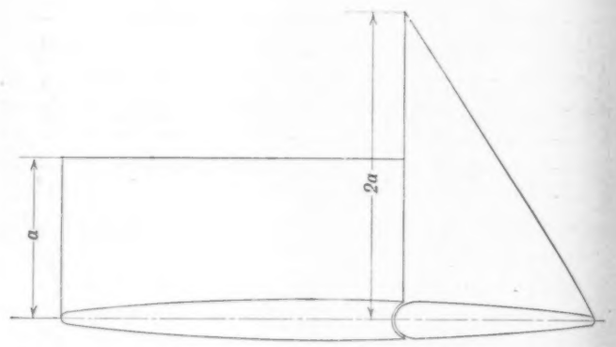


FIG. 7. LOADING ON STABILIZER AND ELEVATOR

(4) Check this up against the diving speed of the machine on a dive at 50 degrees and the maximum lift coefficient. If the computed lift coefficient is reasonable, assume that this mean loading holds, and also if the lift coefficient indicates that the elevator is turned up to a big angle, assume that the mean

FIG. 8. ARRANGEMENT OF SUPPORTS DURING TESTS OF HORIZONTAL TAIL SURFACES

(2) From leverages of the control system, calculate the maximum moment which will be exercised about the elevator hinge, and

(3) From this maximum moment about the elevator hinge, and assuming the loading on the elevator to vary uniformly loading on the stabilizer is equal to the mean loading on the elevator.

(5) For a very small machine, it might turn out that the pilot's strength would be far in excess of any resisting effort the surfaces could oppose. In such a case it is necessary to

find the diving speed at 50 degrees of the machine, assume a maximum lift coefficient of about .003 (in lb./sq. ft. per m. p. h.) and design or test the tail surfaces from this point of view.

(6) For a very large machine, it might be that the pilot's effort would, even with balanced surfaces, give a low loading on the tail surfaces. In such a case, the elevator is turned up only to a small angle relative to the stabilizer, and the loading on the stabilizer should be greater than the mean loading on the elevator.

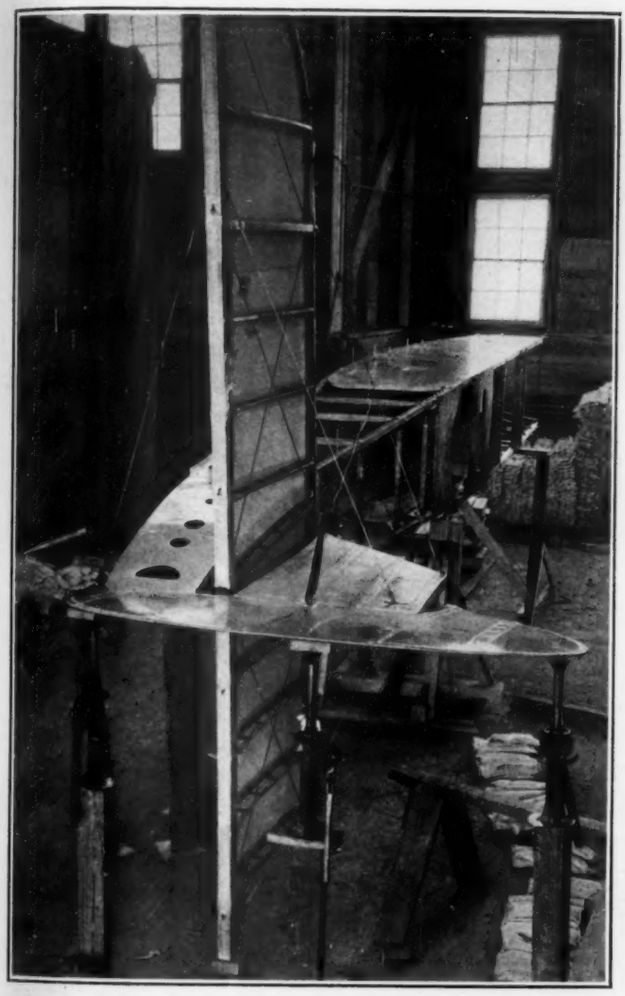


FIG. 9. METHOD OF SUPPORTING FOR RUDDER AND FIN TEST

The curves shown in Figs. 3, 4 and 5, give a valuable idea of the actual magnitude of the pressure coefficients for a combination such as the JN-2, which is fairly typical.

Current Practice in Sand Loading for Tail Surfaces.—At the Royal Aircraft Factory, England, the load on both stabilizer and elevator is taken as 20 lb. per sq. ft. distributed uniformly over both surfaces, where the total area of horizontal tail surfaces does not exceed 50 sq. ft. Beyond this point the load per square foot is taken as diminishing somewhat. In the United States Army Air Service the mean loading over stabilizer and elevator is equal, but the loading on the elevator varies from zero at the trailing edge to a maximum at the leading edge, as shown in Fig. 7.

The loading at the leading edge of the elevator is thus twice the uniform loading on the stabilizer.

In the vertical tail surfaces, the Royal Aircraft Factory uses on the rudder 15 lb./sq. ft. mean load with center of pressure ⅓ of the chord from the leading edge. For the fin of the R. A. F. criterion is 10 lb./sq. ft. distributed uniformly on ⅔ of the rudder loading. In American practice the mean loading per square foot is the same for both rudder and fin, but the loading on the rudder, just as for the elevator, is graded from zero at the trailing edge to a maximum at the forward edge.

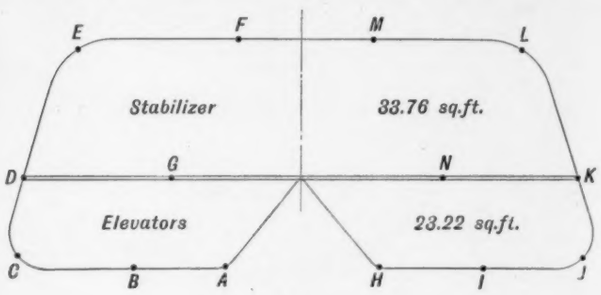


FIG. 10

In view of the uncertainty of our aerodynamic knowledge, it would seem as if the practice adopted in the American army were reasonably satisfactory and, if used consistently, would furnish at least a basis of comparison.

Ailerons are rarely tested, their construction as a rule being far stronger than any loads imposed on them in flight. Experiments in two or three wind tunnels indicate conclusively that for ailerons the wind pressure varies uniformly from zero at the trailing edge to a maximum at the leading edge, with center of pressure at ⅓ of the chord from the leading edge. If an aileron is to be tested, therefore, there should be no hesitation in employing this form of loading.

Actual Procedure in Testing.—The photograph of Fig. 8 indicates clearly the way in which the horizontal tail surfaces are set up for test. The body is placed in a normal horizontal position, is carefully supported on horses, to avoid strain—since the same body may itself be used for testing—and is tied down at the front end by cables to bolts in the floor. When testing the horizontal tail surfaces it is not necessary to attach the rudder, but otherwise the rigging should be as careful as if assembling for a flight. Since the elevators deflect considerably under load, it is essential to turn them up a few degrees at the beginning of the test as shown in photographs. Just as in testing wing surfaces, supports have to be provided for against the possibility of a complete break-down, and these are clearly shown in the photograph. Jacks are employed in supporting the elevators in a similar manner, as on

TABLE I

Deflections														Load per Sq. Ft.	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	Elevator	Stabilizer
3¾	3⅞	4⅜	½	⅜	0	⅛	4½	4⅜	1¼	⅜	⅛	⅛	¼	8 lb.	8 lb.
7¼	7½	8	⅞	½	⅜	¼	6½	6⅜	6½	¾	⅛	¼	⅜	12 lb.	12 lb.
						Left Elevator		Failed						16 lb.	16 lb.
						Right Elevator		Failed						20 lb.	20 lb.
....	....	....	¾	1¼	⅛	¼	....	....	....	1⅜	1½	⅜	⅜	....	28 lb.
....	....	....	1	1½	¼	¼	....	....	....	1½	1⅞	⅜	½	....	36 lb.
....	....	....	1½	2½	⅜	½	....	....	....	1⅞	2½	⅝	⅝	....	48 lb.
....	....	....	....	3⅛	⅞	⅝	....	....	....	3¼	4⅝	1⅛	⅞	....	60 lb.

the wing truss, being applied when it is desired to put on a fresh increment of load and released at the time when deflections are to be taken. Yard-sticks are employed at the points where deflection measurements are taken.

While testing the elevators and stabilizer, it is also possible to test the entire control system, by connecting up the elevator loads to the joy stick itself, and fixing the joy stick in position. It is sometimes thought advisable to connect the joy stick to a spring balance so as to measure the actual effort exercised by the pilot for a given load on the elevator.

In the photograph of Fig. 9 is shown a set-up of the vertical tail surfaces. In this case the elevators are generally removed, but the stabilizer remains in position, since the vertical fin has to be braced to this. In this case the body is placed on one side, and since the loads on the fin and rudder are not symmetrical relative to the body it has to be suitably supported to prevent twisting. In the test illustrated in Fig. 9 this was done by placing a post at one side, and tying down on the other side.

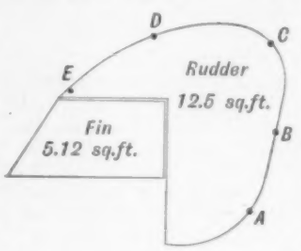


FIG. 11

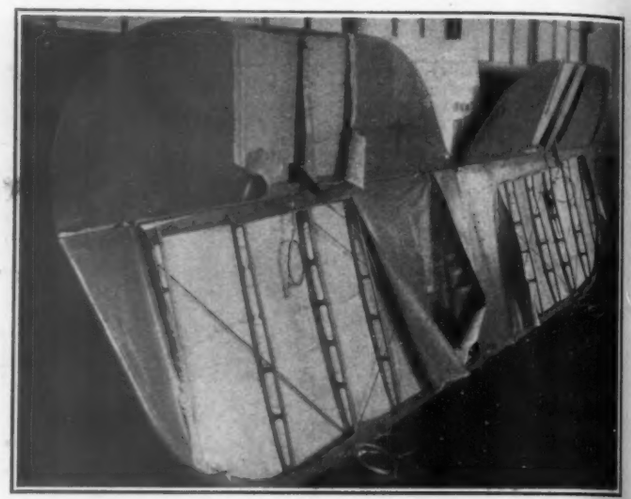


FIG. 12. ELEVATORS AND STABILIZERS AFTER FAILURE

In conducting the test it saves time and trouble (*a*) to have a load chart ready before the test, (*b*) to divide the surfaces suitably by strings stretched across them, (*c*) by piling the sand in some regular fashion on the ground. In measuring de-

TABLE II

Average load per sq. ft.	Deflections A	B	C	D	E	Remarks
0–3	3/8	1/4	1/8	1/8	—1/4	
3–6	7/8	1 1/8	1 3/8	3/8	—1/4	
6–9	1 1/2	1 5/8	1 3/4	1/4	—1 7/8	
9–12	1 3/4	1 5/8	1 5/8	1/4	—1 1/4	
12–15	2 7/8	2 5/8	2 5/8	1/4	—1 1/2	
15–18	2 7/8	3 3/4	4	3/4	2 7/8	
18–21	Mast connection failed					

TABLE III

	1	2	3	4	5	6	7	8	9	10
Type	Single Seater Training	Single Seater Training	2-Seater Primary Training	2-Seater Advanced Training	Advanced 2-Seater Training	Single-Seater-Scout	2-Seater-Fighter	2-Seater-Fighter	2-Seater-Fighter	2-Seater-Reconnaissance or Night-Bomber
Type of Tail Surface Construction	Usual wooden type	Steel Tubing Wood Spars	Brazed Tubular Construction	Tubing and Wooden Ribs	Steel Tubing	Spruce Ribs and spars, Edges Tubing	Fabricated Steel	Spruce and Veneer	Spruce and Veneer	Usual wooden type
Gross Weight	1200 lbs.	1200 lbs.	....	1900 lbs.	2200 lbs.	1800 lbs.	3600 lbs.	3000 lbs.	3500 lbs.	4900 lbs.
Power	80 H.P. Le Rhone	80 H.P. Le Rhone	100 H.P. Curtiss	Hispano-Suiza 150 H.P.	150 H.P. Hispano-Suiza	Hispano-Suiza 180 H.P.	Liberty 400 H.P.	Liberty 400 H.P.	Liberty 400 H.P.	Liberty 400 H.P.
Area of Stabilizer	12.2 sq. ft.	12.1 sq. ft.	....	19.2	....	14.6 sq. ft.	34	27	17	....
Wt. of Stabilizer/sq. ft.	.655	0.87	....	....	....	1.1	.794	.7	.825	....
Area of Elevators	13.3 sq. ft.	12.7 sq. ft.	....	17.2	....	15.2	26 1/2	30	28	....
Wt. of Elevators/sq. ft.	.89	1.06	....	....	....	.7	.794	.80	.84	....
Failing Load and Cause of Failure for Horizontal Surfaces	37.5 lbs./sq. ft. Failure in Stabilizer Ribs	45 lbs./sq. ft. Ribs bent	17 1/2 lbs./sq. ft. caused warping of elevators. 35 lbs./sq. ft. failed elevator mast	32.5 lbs./sq. ft. trailing edge started to bend	....	Stick failed at 27.5. At 32.5 secondary spar failed at attachment of control mast wire	42 lbs./sq. ft. Elevator Ribs Buckled	12.5 lb./sq. ft. Elevator Mast Buckled	Torque tube at 10 lbs. Entire System at 20 lbs.	17.5 lbs./sq. ft. Failure of masts by lateral bending.
Area of Vertical Fin	2.35 sq. ft.	2.06	....	2.4	....	4.6	7.25	4	3.4	....
Wt. of Fin/sq. ft.	.585	0.97	....	8.6	....	.72	.86	.91	.81	....
Area of Rudder	5.4 sq. ft.	6.9	....		11.0	5.4	12 1/4 sq. ft.	10	10	....
Wt. of Rudder/sq. ft.	.7	0.80	....		.96	.95	.86	1	.765	....
Failing Load and Cause of Failure for Vertical Surfaces	42.5 lbs./sq. ft. Failure Rudder Spar	60 lbs./sq. ft. rudder mast in lateral bending	....	35 lbs./sq. ft. after reinforcement. 15 lbs./sq. ft. rib to which mast attached. Mast failed at 45 lbs./sq. ft.	25 lbs./sq. ft. steel tube to which mast attached	Rudder Mast at 45	44.8 lbs./sq. ft. Rudder Ribs Bent	Rudder Mast at 17.5 lbs./sq. ft.	Rudder Mast Crushed at 30 lbs./sq. ft.	....

flections of the elevators or stabilizer, it is very important to have no give to the fuselage itself, and to support it by an end post. Also it is necessary to bring back the joy stick to its original position, which can be easily done by tightening up on the ropes holding the spring balance. Slack in the control leads can be taken up by turnbuckles. These and other minor adjustments require some e perience in the engineer conducting the tests.

It should be noted that in testing the stabilizer and elevator it is customary to load in the following increments: 5 lb./sq. ft.; 5 lb./sq. ft.; 2½ lb./sq. ft.; 2½ lb./sq. ft. until failure of the elevators takes place. The test on the stabilizer is then continued with increments of load of 10 lb./sq. ft. Similar loadings are made for rudder and fin.

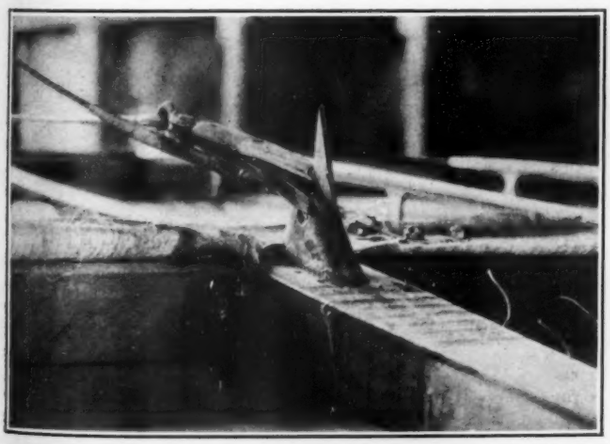


FIG. 14. RIGHT HAND ELEVATOR MAST AFTER FAILURE

In Figs. 10 and 11 are shown some typical deflection values for a test of horizontal and vertical tail surfaces.

Results of Tests on Surfaces of Machines in Current Practice.—Since our requirements for the strength of tail surfaces are on a somewhat unsatisfactory basis, it is most interesting to tabulate results of tests for a number of airplanes, whose characteristics are given without specific reference to their makers in Table III.

Some Interesting Failures.—From the testing of a wide range of tail surfaces, the author is led to believe that many failures occur in the control system itself, many more occur in the attachment of elevator masts and rudder masts, and that the main structure of both moving and fixed surfaces are almost always strong enough. Figs. 12, 13 and 14 illustrate a series of representative failures.

Fig. 12 represents a set of horizontal tail surfaces from a two-seater fighter of a gross weight of 3550 lb. and a horse-power of 400. The entire structure is in good shape, and there is just the local failure (occurring at 20 lb./sq. ft.) on the main rib to which the elevator mast is attached, due to the fact that the mast is attached on the side of the rib, producing combined twisting and bending, with a consequent splitting of the rib. Such an error in detail vitiates the whole design.

FIG. 13. FAILURE OF AN ELEVATOR AT 32.5 LB./SQ. FT.

Fig. 13 shows an elevator described in column (6) of Table III. 32.5 lb./sq. ft. the failing load is amply strong, but again while the main structure of the elevator remains sound, the fact that the brace wire was carried to the secondary spar at some distance from the main rib weakened the design.

In Fig. 14 is shown a failure for the large reconnaissance machine of Column 10 in the table. The control cable, the mast and the main rib were not in line, with the result that the mast failed in lateral bending at the low figure of 17.5 lb./sq. ft.

These are but a few of the examples of error in detail spoiling an otherwise perfectly good design.

Book Review

THE PROPERTIES OF AEROFOILS AND AERODYNAMIC BODIES. By Arthur W. Judge, A. R. C. Sc. (J. Selwyn & Co., Ltd., London and New York. 149 figs.)

Mr. Judge's book is frankly a compilation of aerodynamic data from the reports of the British National Physical Laboratory, Eiffel's Laboratory and other wind tunnels. Nevertheless, it is illuminated by a scientific presentation of underlying theory, and is carefully and systematically arranged. Published in 1917, it does not, of course, contain the results of recent experimental work, but certainly covers all pre-war material. Eiffel's data for the flat plate are fully summarized. A very fair selection of aerofoils is given, together with the study of the effects of varying camber, varying position of maximum ordinates, etc. Biplane combinations are somewhat briefly considered. The resistance of aerodynamical bodies includes airship hull shapes, cylinders, spheres, cones, airplane bodies, struts, etc. The analysis of the resistance of a monoplane is a useful reprint. Tables for over fifty aerofoils are appended.

The Bellanca C. E. Biplane

The Bellanca C. E. two-seater biplane, with a 55 hp. Anzani engine, has been designed to meet the requirements of quick get-away, fast climb, and very high speed, and—at the same time—a very low landing speed, such as insures the greatest degree of safety. Consistent with these qualities, the design and construction embrace light weight and economic upkeep to the most satisfactory degree. An acceptable feature lies in the rapidity and ease with which the machine can be dissembled and re-assembled.

General Description.—Best selected white ash is used for the principal parts of wings, body, undercarriage, etc.

Brazing and welding have been eliminated wherever possible. Care has been observed to avoid the piercing of longerons and other vital members. The assembling facility is such that in 30 minutes it can be dismantled and in about 40 minutes it can be re-assembled ready to fly.

Safety Factor.—The factor of safety of lift stresses on the beams of upper and lower wings is 12, and the factor of drift stresses is 14. In the body the safety factor is 12, which is also the safety factor of the weakest point of the whole machine.

GENERAL SPECIFICATIONS

Span, upper plane	28 ft.
Span, lower plane	21 ft. 5 in.
Chord, upper plane	4 ft. 6 in.
Chord, lower plane	2 ft. 9 in.
Total area	184 sq. ft.
Length overall	18 ft. 6 in.
Weight, machine empty	470 lb.
Useful load	510 lb.

PERFORMANCES WITH USEFUL LOAD OF 250 LB.

Useful load of 250 lb.:	
Pilot	150 lb.
Fuel for 3-4 hours' flight	100 lb.
Maximum speed	101 m.p.h.
Minimum speed	34 m.p.h.
Rate of climb, first minute, ft. per min.	1,020

PERFORMANCES WITH FULL USEFUL LOAD OF 500 LB.

Full load of 510 lb.:	
2 passengers	300 lb.
Fuel for about 3 hr. flight at full power or about 4 hr. throttling the motor to 40 hp.	110 lb.
Other load which can be sufficient for nearly as much fuel as above, or other load	100 lb.
Maximum speed	97 m.p.h.
Minimum speed	41 m.p.h.
Minimum horse-power required for horizontal flight.	14
Rate of climb, first minute	600 ft. per min.

PERFORMANCES WITH USEFUL LOAD OF 400 LB.

Useful load of 400 lb.:	
2 passengers	300 lb.
Fuel for 3-4 hr.	100 lb.
Maximum speed	99 m.p.h.
Minimum speed	38 m.p.h.
Minimum horse-power required for horizontal flight.	11
Rate of climb, first minute	780 ft. per min.
Climb in 10 minutes	6,000 ft.
Climb in 15 minutes	7,500 ft.
Climb in 27 minutes	10,000 ft.

PERFORMANCES WITH VERY LIGHT LOAD

Useful load, pilot and one hour of fuel	185 lb.
Maximum speed	102 m.p.h.
Minimum speed	32 m.p.h.
Minimum horse-power required for horizontal flight.	7
Rate of climb, first minute	1,180 ft. per min.
Climb in 10 minutes	9,000 ft.
Climb in 12 minutes	10,000 ft.
Climb in 25 minutes	15,000 ft.

THE 35 HP. BELLANCA BIPLANE, WHICH IS SIMILAR TO MODEL CE, EXCEPT FOR WARPING WINGS AND A SMALLER ENGINE

Main Planes.—The dynamical stability of the planes is almost the same as the Eiffel 32.

Spars are of ash. Struts between planes are of streamline section and of constant depth for two-thirds their length. Ends taper to the strut fittings.

Controls.—Lateral and longitudinal balance is operated by stick control. The rudder is balanced; it is operated by the foot bar.

Lateral control is obtained by ailerons and their effect is immediate in answering to the slight movement of the stick.

Body.—The body is of exceptionally good streamline form. Its wooden frame is of box-girder construction, braced by cables from the pilot's cockpit forward and with wire from the same cockpit rearward. The nose is covered with aluminum, a round door in one side giving access to the engine. The remainder is covered with linen, doped and varnished. The front deck is of veneer, linen covered.

Undercarriage.—This is of the ordinary V type, each V consisting of two ash laminated streamline struts, joined together by steel aluminum plates. Rubber shock absorbers secure the axle to the struts.

Tail Group.—The empennage is composed of a non-lifting horizontal stabilizer, to which the elevator flaps are fastened. The attachment of the stabilizer is such that it is easily detached by removing four cotter pins. The rudder is of oval shape and is of sufficient area to insure complete control in handling the machine on the ground.

Engine Group.—An air-cooled 6-cyl. Anzani 6-C type, 55 hp. is used. Its weight is 154 lb. Propeller is 7 ft. in diameter. The engine is so attached as to form, with the rest of the body, a perfect streamline form with low head resistance.

Only part of the cylinders are exposed, which are effectually cooled by the speed of the machine when in flight.

The Direct-Lift Machine

By Sidney Camm

Much of the scepticism and ridicule with which any mention of the helicopter is too often treated is undoubtedly due to the lack of knowledge existing with regard to what has been accomplished by experiment with full-sized vertical lift machines, the results in many cases proving that it is not only a theoretic, but a practical certainty. Unfortunately, the utility of the type is apparently confined to one attribute, and it seems that, in the attainment of this, other just as vital factors are to be sacrificed, and, moreover, the possibility of the achievement does not necessarily prove its desirability. However, before considering the relative advantages of the airplane and the helicopter, some indication of what actually has been accomplished, as distinct from probabilities inspired mainly by hope, will show the extent to which experiments have been carried, and the really remarkable results obtained. Of the total number of patents registered concerning aeronautics, an enormous percentage relate to the helicopter in one form or another, and it is also noticeable that long before flight with the airplane assumed even the semblance of possibility, a great deal of thought had been expended on the helicopter as the form of machine with which successful flight would eventually be accomplished.

Early Experiments

Probably the earliest known form of helicopter is to be found in the model of feathers and twisted thread made by two Frenchmen in the latter part of the seventeenth century, a similar model being made by Sir George Cayley in England in 1796.

Much later, in 1907, the first instance of successful flight with a helicopter carrying its own power occurred, and it is also extant as the first reliable experiment. The designer, a Frenchman named Cornu, had previously, in 1906, carried out extensive experiments with a power-driven model, and had obtained some encouraging results. Two lifting screws over 7 ft. in diameter were placed side by side, and driven by a 2-hp. Buchet motor, lightened up to weigh only 15 lb., the transmission being by a single belt over jockey pulleys, the rest of the structure being of steel tubing, the complete model weighing 28 lb. With the motor not developing full power a thrust of over 30 lb. was obtained, the model lifting easily, and, moreover, describing a circular flight. An interesting point about the Cornu helicopter was the attempt made to obtain translational movement, as well as direct lift from the screws.

This was achieved by two planes attached to the main framework, so that the angle of incidence could be adjusted. The reaction of the slip stream of the air-screw acting upon these planes gave the horizontal movement. In the full-sized machine the motor used was a 24-hp. Antoinette, the lifting screws being of the two-bladed variety and over 19 ft. in diameter, built of steel tubing and covered with rubber-proofed silk. In the trials with this machine an almost insuperable difficulty was encountered in the constant slipping of the leather belt forming the transmission.

Further Developments

Various alterations were effected, and during a trial towards the end of 1907 the machine with M. Cornu aboard lifted clear of ground and remained so several minutes, the height being regulated by cords. The total weight lifted on this occasion was 572 lb., and it is estimated that the maximum power developed by the engine did not exceed 14 hp. Owing to lack of financial support, a reason too often the cause of the abandonment of a promising design, the experiments, which had been developed to the construction of a combination of airplane and helicopter, were discontinued.

The combination of helicopter and airplane, which apparently possesses greater chances of success, has attracted various enthusiasts, some notable results being obtained by the Frenchmen Bréguet and Richet. They are both better known to the aviation world as the originator and pilot of practically the first all-steel airplane. The Bréguet gyroplane, as that combination of helicopter-airplane is sometimes described, took the form of a biplane of approximately 540 sq. ft. of surface. The lifting screws were placed at the wing extremities, between the upper and lower planes, the shafts being inclined forward to obtain some measure of horizontal motion. Each screw was actually composed of two four-bladed screws, one being mounted directly over the other, the diameters being 26 ft. The motive power was derived from an Antoinette of some 45 hp., the machine weighing, complete with pilot, over 1250 lb. Under test, the machine lifted several times, on one occassion traveling some distance. However, realizing probably that successful flight was uncertain of accomplishment, Bréguet suspended his experiments with the gyroplane, and embarked on the airplane type of machine.

The Davidson Experiment

Another direct-lift machine, which never, at least in this country, reached the practical testing stage, was the Davidson gyropter. The experiments from which the machine built in England was designed were carried out in America, very encouraging reports being received, although these were not definitely authenticated. The machine built in England was of colossal dimensions, but, unfortunately, owing to lack of funds, it never reached the stage of completion.

At the 1913 Aero Show at Olympia was exhibited an entirely original conception of the vertical lift type of machine, this being the Porter "gyropachute." In this case a 50 hp. Gnôme mounted horizontally drove a multi-bladed screw, or paddle-wheel. Around this, upon a framework of steel tube, was arranged a bell-shaped fabric-covered structure, with a circular opening at the top.

It was intended that the volume of air displaced radially by the rotation of the paddle-wheel would be deflected downwards by the bell-shaped arrangement, the consequent reaction providing the vertical lift. Horizontal motion was to have been obtained by the alteration in angle of a fabric extension of the bell-shaped body, controlled from the pilot's seat, the latter item being suspended from the engine mounting. It is interesting to note that, in this case, an exigency not always allowed for in the general design of helicopter—engine failure—was provided for by the parachute action of the body. In addition to the cases referred to, there are innumerable instances on record of the production of helicopters, some purely so, others a combination of fixed plane and vertical lifting screw, but in almost every case the experiments were abandoned for want of financial support.

Financial Difficulties

Many will remember that the development of the airplane in this country was seriously hampered by a similar deficiency. The direct-lift enthusiasts are unanimous in ascribing the absence of convincing results to this lack of support, but it is conceivable that had this been forthcoming the impracticability of the helicopter, which is now largely a matter of opinion, would have been convincingly demonstrated.

A considerable number of experiments with propellers acting as lift screws have been made, with relatively encouraging results.

In one case, with barely 9 hp. applied at the propeller shaft, and a screw of 15 ft. diameter, the lift obtained was 27 lb. per hp. Unfortunately, when it is desired to increase the size of screw and machine to that necessary for practical flying, the experimentalist encounters precisely the same trouble as that affecting the development of the airplane, known generally as the two-thirds power law. This implies that, if we wish to obtain twice the thrust from a given screw, the horsepower applied would have to be cubed, or, conversely, twice the horsepower applied to a given screw will only produce approximately 1.6 times the initial thrust. A proper appreciation of this fundamental point would undoubtedly have deterred many of the experiments made.

The Advantages of Vertical Lift

The essential advantage of the vertical life machine is its ability to rise from any sort of ground or confined space, an attribute which the modern airplane certainly does not possess.

It would also attain the desired height by a vertical flight

* Courtesy of *Flying* (London).

upwards, instead of the circling flight in a gradient determined by the amount of surplus power over that necessary for horizontal flight with the airplane. The characteristic of direct ascent is of supreme importance from a military aspect, for then it would be possible to keep an enemy in sight whilst rising to attack; bomb-dropping might be carried out with greater precision, owing to the machine's capacity to hover, and this latter item would also render observation more reliable.

Possibilities of Combination Machines

Assuming the production of a revolutionary motive power, or the reduction in weight of the present type of motor, to limits at present impossible of achievement, one cannot deny that there are possibilities in a combination of helicopter and fixed plane machine. At the same time the chances of the helicopter superseding the airplane as the type of the future would not be improved, simply because the production of an extremely light motor would greatly enhance the performance of the airplane, particularly in the matter of climb. A motor of 1 lb. per hp. or less would enable the present-day type of airplane to approach very closely to the ideal of vertical climb, and in the writer's opinion this is the direction in which future improvements will occur. The principles of airplane design are a long way from finality; indeed, there are vast fields yet open to research.

Although it must be admitted that the airplane as at present constituted suffers from the want of a low-landing speed, it is more than certain that this will eventually be solved by the production of a variable incidence machine, while the variable pitch air-screw is another source from which the airplane of the future will gain increased efficiency. It, therefore, does not seem possible that the helicopter as a type will ever supersede the airplane for practical purposes, though it may admittedly be possible to produce such a machine.

Trend of German Airplane Design*

Enemy airplanes which have been captured intact or reconstructed have, under test, generally shown themselves poor in performance, judged by British standards, especially in point of speed at heights; but it would seem that as a rule they are fairly good in point of climb, and notably good in regard to maneuverability.

Wing Sections

In general they do not differ very markedly from British wing sections, though there is a distinct tendency towards rather greater camber. It is thought probable that this principle has been adopted so as to yield better results at high altitudes when the angle of incidence would necessarily be somewhat big.

Practically all German airplanes have a pronounced wash-out at the top of the trailing edge. In the most recent example of Halberstadt design, namely, the C4 type, the lower wings are given a heavy wash-out at their junction with the bottom of the body, the idea being to minimize the surface of discontinuity which would otherwise exist between the bottom surface of the body and the wing roots. Thus the front spar is straight, but the rear edge is markedly concave. This effect exists to such an extent that the trailing spar is considerably bent as well as twisted.

The Fokker wing section is in a class by itself, not only on account of its great depth, but also in having only a very slight camber on the bottom surface. The performance of this machine is, however, by no means despicable, and it is generally conceded to be a redoubtable opponent.

Bays

As far as single and two-seater machines are concerned, the usual wing construction involves a single pair of struts at each side, but it is noticeable that in the latest model Pfalz scout, the D12, this practice has given place to double pairs of struts. Indications point to great strength having been made a matter of prime importance in this design.

In some types, notably the Pfalz and the Fokker, the upper plane is made as a single unit. In the latter case the lower plane is also in one piece. In the generality of machines, however, the center section principle appears to be gaining vogue.

Spars

Shortage of ash and spruce has led to the general adoption of built-up spars, which are of such a variety of types that a separate report is being issued upon their design. In nearly all cases ply-wood plays an important part. Thus in the Fokker biplane the spar, which, owing to the absence of the usual wire bracing of the wings, is extremely deep, consists of two thin rails of spruce united by deep ply-wood webs. In the Gotha bomber a built-up I section spruce spar is covered in with ply-wood at each side. On the Giant four and five-engined bombers the spars are of hollow rectangular section, strengthened by a transverse web across the middle of the box. The latter is built of numerous components tongued and grooved together. The whole is strengthened by walls of multiply glued on each side. In the Halberstadt design the built-up spruce spars are reinforced by broad horizontal webs of ply-wood running longitudinally, and at each edge of these are stringers. The whole spar construction thus represents a section similar to an H lying on its side, of which the central box spar forms the cross bar.

The A.E.G. machines alone employ steel tubular spars.

Other German designs, such as the Pfalz, D.F.W., L.V.G., Rumpler, and Albatros, employ built-up spars of the ordinary accepted type, either of box or I section.

Wiring

With the exception of the Fokker biplane and triplane, which have no external wire bracing whatever in the wings, the rigging of German machines is upon the accepted lines. The standard material is multi-strand cable furnished with whipped and sweated splices at the loops. Quick detachment devices, which at one time were fitted on several German models, have now disappeared. For internal wiring both plain wire and stranded cable are used. In the Fokker design the angle of the drag bracing cables between the struts seems to be very bad, but according to reports this machine is actually unusually strong. Drag bracings are in some cases taken from the front of the body, but in most designs are confined to the interior of the wings. In no case is the undercarriage used to form a component of the bracing system.

In most machines the compression struts between the spars, for drag bracing, are steel tubes, but in some cases, notably the Fokker, Halberstadt and Albatros, wooden box ribs are used.

Bodies

The standard type of German body construction embodies a three-ply shell built up on light wooden formers. It is generally of the wireless form, but in some cases the forward portion in the neighborhood of the wings and engine is strengthened with diagonal bracing. This is adopted also in the Gotha in that part of the body which embraces the cockpits and fuel tanks.

Exceptions from this general rule are the A.E.G. two-seater, the A.E.G. bomber, and the Fokker (biplane and triplane). In all of these steel is exclusively used for the body construction, the transverse members being welded to the longerons. In the four and five-engined Giant bombers the rear portion of the body, including the longerons, is of steel tube, while in the Friedrichshafen bomber wooden longerons are used in conjunction with steel tube compression members.

In nearly all cases the wooden body is roughly rectangular in section, with corners rounded off, and tapers to a vertical knife-edge at the rear. In the Halberstadt, on the contrary, it tapers, in a manner similar to that of the Bristol fighter, to a horizontal edge. In the Pfalz designs great pains have been taken to produce a fish-shaped body of perfect stream-line form; this is of approximately elliptical section throughout, though leaning toward a sharp "backbone" near the tail. The performance of this design is, however, relatively poor, and the

* Excerpt from a report by the Technical Department of the British Air Ministry

rather elaborate stream-lining appears to bring no great material benefits.

In the Albatros and the earlier Pfalz the fin is built in one with the body, and very neatly faired off; but it is notable that in the latest Pfalz this practice has been discarded in favor of a detachable fin.

Tail Surfaces

The use of fixed fins and tail planes is now standard on all German airplanes, and in nearly all cases both the rudder and elevator are balanced. In some cases—notably the Fokker biplane—the fin is offset so as to mitigate the turning effect due to the swirl of the slipstream. In the Hannoveraner fighter a biplane tail is incorporated with a view to reducing the blind area of the movable machine gun.

In all the big bombers—the Gotha, the Friedrichshafen and the Giant machines of both types—a biplane tail is now a standard fitting, though it has not yet been adopted on the A.E.G.

In practically all cases the framework of the tail organs is of light steel tube, and in general this applies to the fixed planes as well as to the controllable surfaces. In the Pfalz, Albatros and L.V.G. designs the fixed plane frames are of wood and covered with thin ply-wood.

In some cases—notably the A.E.G. bomber—the fixed planes are of heavily cambered stream-line section. The same practice, though to a less noticeable extent, is embodied in the latest Halberstadt; but in the Fokker, which is to be regarded as one of the most up-to-date German types, flat, uncambered surfaces are exclusively employed. In this case, too, the fixed tail plane is made in one unit and dropped into brackets on the top side of the body, instead of being constructed in two halves, and placed one on either side. This principle has also been adopted in the most recent Halberstadt.

Struts

Probably owing to a shortage of timber wooden interplane struts are very little used, and are only found in the Friedrichshafen, L.V.G. and the older type of Pfalz. Steel struts are either tubes of round section faired off with a three-ply or solid wood stream-lining, or of oval section, the latter practice being increasingly popular. In some cases the strut ends are tapered and welded to a socket; in others the tube is kept full section and is dropped over an eyebolt at each end. N-struts for the junction of the top plane and the body are common, and are also used between the planes in the Pfalz and Fokker models. Oval steel tubes for undercarriage struts are practically universal, the L.V.G. being the only design incorporating wooden members in this position.

Undercarriage

For scouts and two-seaters the plain axle slung to V-struts is invariably adopted. In most cases neither the axle nor the tie rod are faired off, but in the Fokker types, both monoplane and triplane, the axle fairing has been developed into a lifting surface. In the larger bombing machines current practice varies considerably. Thus in the Friedrichshafen there are three two-wheeled axles—one under each engine and the third under the nose of the body. This system has been adopted in some of the Giant airplanes. In the Gotha there are two two-wheeled axles under each engine, while in the four-engined Giant under each engine unit is a ponderous single axle supporting at each end four wheels placed side by side.

Shock Absorbers

Rubber bands have now entirely disappeared, and their place has been taken by steel coil springs. In some cases three coils, of alternate "hand," are placed one inside the other; in others three small coils are grouped together in a "clover leaf" and covered in with cotton fabric. The weight of spring used on the average machine is about 5 lb. for each wheel. In the Gotha the shock-absorber springs are concealed in the undercarriage struts, and are worked by a cable passing over pulleys. Steel-shod wooden tail skids are almost always used, but are not made steerable.

Engine Bearers

In most scouts and two-seaters wooden bearers, sometimes of ash, but more often of pine, are supported on multi-ply-wood bulkheads, but in the Fokker and A.E.G. designs the construction is of steel tubes, to which flat clips are fixed for the support of the crankcase arms. In the A.E.G. bomber the bearers are hollow steel of rectangular section. Owing to shortage of suitable timber the bearers on the Giant airplanes, which are necessarily very long, are built up of a soft wood center piece, reinforced top and bottom with five half-inch layers of ash.

Radiators

Several types of radiators are in use on German airplanes, and in nearly all cases they are fitted with some simple form of shutter, which is used in conjunction with an electrical rheostat thermometer. Formerly it was the general practice to mount a rectangular radiator in front of the cabane, just underneath the top plane; but in the latest L.V.G.'s this method has been discarded, and a curved radiator sunk flush in the center section is adopted in its place. Generally speaking, this plane radiator is now standard in two-seater designs, but in the Pfalz, which previously incorporated this scheme, the latest pattern has a nose radiator of vertical tubes, the arrangement being somewhat similar to that of the Fokker biplane; these two machines are in this respect in a class by themselves.

On bombers the usual design embraces a car type radiator at the front end of the engine bearers, but in the four and five-engine Giant machines the use of gear boxes has prevented this practice being adhered to, and in these the radiators are carried well up above the motors, and fixed either on the engine bearer struts or on wires.

In the flush pattern of radiator the tubes are horizontal and of flattened oval section, and are set with their major axis inclined. The tubes are in two cells, which are separated by baffle plates, which insure that the water runs from side to side, then down, and then from side to side back again. A short-circuit tube is nearly always provided to guard against the formation of air locks in the upper portion of the water tank. Another fitting frequently met with is a small subsidiary water tank mounted above the radiator and connected to the main filler cap with a tube. The top of this tank is fitted with a trumpet-shaped nozzle pointing forward.

Gears

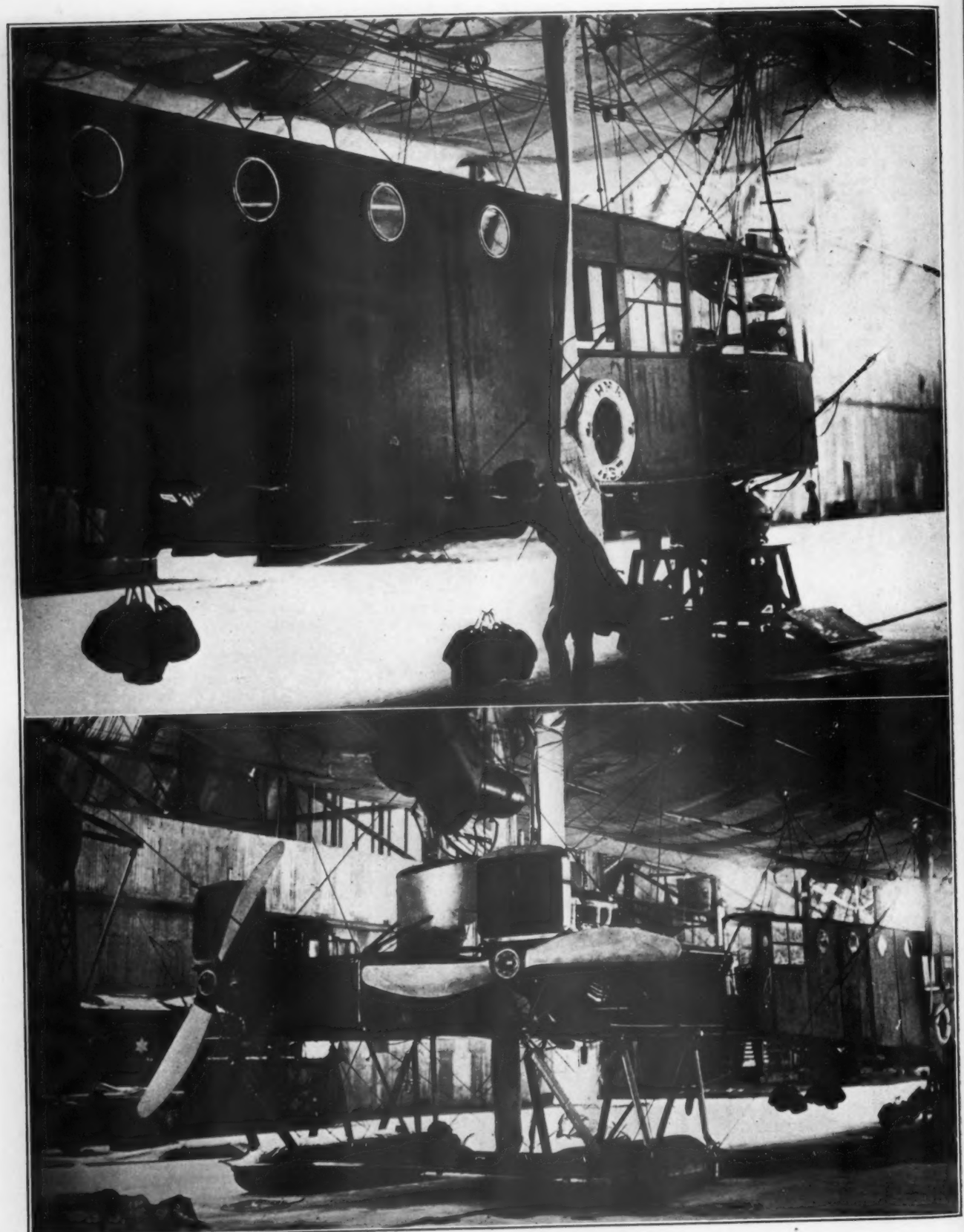
It is significant that in the four and five-engined Giant airplanes massive gear-boxes are used in conjuction with standard engines of the Mercédès and Maybach type. As might be expected with six-cylinder engines, the gear-boxes are very heavy. In the four-engine machines they had shallow casings fitted with cast aluminum cooling fins, and were connected to the engines by flexible couplings and external shafts. In the five-engine design the shafts are enclosed within the gear-box. Plain spur pinions are fitted, and the ratio employed both for tractor and pusher screws is 21/41. The gear-boxes are of two distinct types—a short one for the tractor screw and a long one for the pusher. The latter is given considerable overhang in order to obviate the need for cutting away a section of the trailing edge to give clearance for the screw.

Each gear-box, including the flywheel on the engine which it necessitates, the flexible coupling and the oil radiator, adds a weight of 346 lb.—a little over 1.15 lb. per hp. It is obvious, however, that the gain in propulsive efficiency is considerable.

The oil radiator referred to consists of a semi-circular tank slung under the gear-box, and containing 65 tubes of, roughly, 20 mm. diameter. Oil is circulated through this, and the sump in the gear-box by a pinion pump driven through worm gears and a flexible shaft from the driving pinion shaft of the gear-box.

Gasoline Systems

These generally incorporate two tanks—one gravity and one under pressure supplied by an engine pump—except where Benz engines are installed. In this case a gasoline pump is employed, which supplies a tubular chamber, from which the overflow returns to the main tank; a hand gasoline pump of the semi-rotary type is used for filling the gravity starting tank. The last-named is frequently let flush into the center section of the upper plane, or is strapped on to it, except in the D.F.W. and Pfalz designs. In the former it is placed on the top of the main tank and forms the back of the pilot's seat; in the latter it is under the engine cowling. In the Fokker the main, auxiliary and oil tanks are incorporated in one unit, and a hand-pressure pump is fitted for starting purposes.



CAR AND POWER PLANT OF A BRITISH NAVAL AIRSHIP OF THE N.S. CLASS, ONE OF WHICH RECENTLY MADE AN ENDURANCE FLIGHT OF 101 HOURS, AND A ROUND TRIP IN THE NORTH SEA OF 1285 MILES

Central News Photo Service

Performance and Cost of the Air Mail Service

COST OF OPERATION AND MAINTENANCE, JANUARY, 1919

Airplane No.	Gas	Grease and Oil	Office Force	Motor cycles, trucks	Rent, light, Fuel, power Telephone, and water	Misc.	Pilots	Mechanics and Helpers	Repairs and Accessories	Interest on Investment	Depart-mental Overhead Charge	Total
2	$70.21	$30.94	$61.94	$79.98	$55.59	$136.12	$135.84	$382.14	$29.95	$97.34	$140.15	$1,220.20
3	177.25	69.88	61.94	79.98	55.59	136.12	386.40	473.05	40.00	97.34	140.15	1,717.70
4	17.93	9.12	29.12	79.98	14.88	136.12	.....	281.41	63.52	97.34	140.16	869.58
38262	109.38	43.46	61.94	79.98	55.59	136.12	232.70	303.20	100.10	97.33	140.16	1,359.96
38274	17.89	6.08	41.94	79.98	26.07	136.12	22.11	291.47	29.95	97.33	140.16	889.10
38275	101.12	42.91	61.94	79.98	55.59	136.12	340.35	306.77	6.00	97.33	140.16	1,368.27
38278	86.10	25.72	61.94	79.99	55.59	136.13	155.25	283.96	29.00	97.33	140.16	1,151.17
38279	60.09	33.41	61.94	79.99	55.59	136.13	196.65	244.40	.....	97.33	140.16	1,105.69
39362	105.97	24.58	61.94	79.99	55.59	136.13	69.88	335.68	31.10	97.33	140.16	1,138.35
39363	35.40	4.86	12.82	79.99	11.19	136.13	.....	40.24	.....	97.33	140.16	558.12
39364	87.92	38.88	61.94	79.99	55.59	136.13	183.42	236.22	108.40	97.33	140.16	1,225.98
39365	84.44	18.59	61.94	79.99	55.59	136.13	77.40	355.93	29.96	97.33	140.16	1,137.46
Total	$953.70	$348.43	$641.34	$959.82	$552.45	$1,633.50	$1,800.00	$3,534.47	$467.98	$1,167.99	$1,681.90	$13,741.58

Cost per mile, overhead, $.4492; cost per mile, flying, $.2785; cost per mile, maintenance, $.5060.

SERVICE AND UNIT COST, JANUARY, 1919

Airplane No.	Gal. of gas.	Total time run hr. min.	Total miles run	Miles run per gal. of gas	Cost per hour	Cost per mile
2	231	11 48	872	3.77	$103.40	$1.3993
3	582	33 34	2,407	4.14	51.17	.7136
4	59	.. ..	....	....	....	....
38262	359	20 13	1,664	4.64	67.27	.8172
38274	59	1 55	128	2.17	463.88	6.9460
38275	333	29 34	1,706	5.12	46.27	.8020
38278	282	13 29	899	3.19	85.37	1.2805
38279	198	17 05	1,157	5.84	64.49	.9521
39362	350	6 04	536	1.53	187.64	2.1237
39363	118	.. ..	....	....	....	....
39364	337	15 56	1,205	3.58	76.94	1.0174
39365	276	6 43	564	2.04	169.34	2.0167
Total	3,184	156 21	11,138	3.50	$87.89	$1.2337

SERVICE AND UNIT COST, FEBRUARY, 1919

Airplane No.	Gal. of gas.	Total time run. hr. min.	Total miles run.	Miles run per gal. of gas.	Cost per hour.	Cost per mile.
2	256	17 44	1,384	5.41	$57.60	$.7374
3	115	6 48	526	4.57	115.20	1.4924
4	161	13 01	918	5.70	79.80	1.1295
7	135	3 26	233	1.73	230.40	3.3982
8	210	8 17	362	1.72	105.60	2.4173
38262	45	0 53	90	2.00	736.20	7.2274
38274	88	5 52	268	3.05	114.60	2.5032
38275	129	4 41	427	3.31	192.60	2.1123
38278	287	28 03	2,172	7.57	42.60	.5517
38279	287	19 18	1,323	4.61	60.60	.8801
38280	124	4 47	346	2.79	185.40	2.5639
39362	316	11 14	899	2.84	90.60	1.1344
39363	568	18 20	1,526	2.69	77.40	.9266
39364	....	.. ..	.....	.....	.....	.....
39365	214	8 51	508	2.37	88.80	1.5429
Total	2,935	151 15	10,982	3.74	90.22	1.2425

COST OF OPERATION AND MAINTENANCE, FEBRUARY, 1919

Airplane No.	Gas	Grease and Oil	Office Force	Motor cycles, Trucks	Rent, light, Fuel, power Telephone, and Water	Misc.	Pilots	Mechanics and Helpers	Repairs and Accessories	Interest on Investment	Depart-mental Overhead Charge	Total
2	$77.94	$30.15	$58.82	$61.66	$46.47	$129.61	$218.31	$244.48	$27.60	$60.43	$65.07	$1,020.54
3	34.93	17.96	58.82	61.66	46.47	129.61	91.37	184.10	34.60	60.43	65.07	785.02
4	52.66	17.09	58.81	61.66	46.47	129.61	120.19	319.13	105.80	60.43	65.07	1,036.92
7	41.28	9.04	58.81	61.66	46.47	129.61	37.69	225.23	56.50	60.43	65.07	791.79
8	63.95	11.54	58.81	61.66	46.47	129.61	136.03	176.21	65.30	60.43	65.07	875.08
38262	17.29	.81	41.51	61.66	19.22	129.61	13.05	226.77	15.05	60.43	65.07	650.47
38274	30.43	8.38	41.51	61.66	19.22	129.61	11.74	226.77	16.05	60.43	65.07	670.87
38275	42.94	14.65	58.81	61.66	46.47	129.61	43.20	319.51	59.60	60.43	65.07	901.95
38278	90.64	27.42	58.81	61.66	46.47	129.61	261.44	368.74	27.95	60.43	65.07	1,198.24
38279	93.90	30.39	58.81	61.66	46.47	129.62	257.26	318.46	42.26	60.43	65.07	1,164.33
38280	41.31	2.04	58.81	61.66	46.47	129.62	44.30	266.18	111.20	60.44	65.07	887.10
39362	96.45	27.14	58.81	61.66	46.47	129.62	133.18	186.46	154.50	60.44	65.07	1,019.80
39363	196.69	58.70	58.81	61.66	46.47	129.62	289.60	401.24	45.75	60.44	65.07	1,414.05
39364	.....	.....	17.30	61.67	27.25	129.62	.....	83.86	.....	60.44	65.08	445.22
39365	96.21	3.41	29.20	61.67	36.19	129.62	142.64	159.32	.....	60.44	65.08	783.78
Total	$976.62	$258.72	$776.45	$924.92	$613.05	$1,944.21	$1,800.00	$3,706.46	$762.16	$906.50	$976.07	$13,645.16

Cost per mile, overhead, $.3822; cost per mile, flying, $.2764; cost per mile, maintenance, $.5839.

Note. Slight increase in cost per hour and cost per mile over January due to short month—24 operating days—and to one plane receiving general overhauling, and one rebuilt.

Converted DH-4 Mail Planes Ready

The twelve DH-4 two-seater fighters and bombers which were remodeled by the L-W-F Engineering Co. to the demands of the Aerial Mail Service, have met all the requirements of the Post Office Department. The pilots who flew them are well pleased with these machines, which are faster and more powerful than the other mail planes.

The L-W-F Co. removed the armament and military accessories and changed the pilot's cockpit from the front to the rear. The front cockpit was then altered so as to provide a rain-proof compartment holding about 500 lb. of mail.

The standard L-W-F undercarriage of bent steel tubing replaces the wooden chassis, and the four longerons of the body are braced from the radiator to beyond the splice in the body. Extra brace wires are attached to the engine section.

The plane carries fuel for 4 hr., which will insure a cruising endurance of 400 miles. The mail planes are just as fast as the battle-planes.

These ships will be used on the New York to Chicago route starting next month.

News of the Fortnight

New Program for Air Service

A new program for the development of the Air Service on a permanent basis has been announced by the War Department. This plan provides for 5,100 planes of all types, 1,700 in active commission and 3,400 in reserve. This is based upon the proposed military establishment of 500,000 men, in which total the Air Service personnel will be 1,923 officers and 21,853 men.

The organization tables show the air forces on a peace basis will comprise eighty-seven service squadrons, of which forty-two will be assigned to coast defence work in the United States and insular possessions, twenty will be pursuit squadrons and twenty-five observation and bombing squadrons. The typical army airplane squadron includes eighteen planes in service and their personnel.

The tables also call for maintenance of forty-two balloon companies, divided into three wings of fourteen companies each.

The general plan of the army reorganization calls for twenty-one divisions, including one cavalry unit of nine regiments, to be formed into five army corps, to be stationed in five different sections of the country, each to be commanded by a lieutenant general. To each corps will be attached five observation and bombing squadrons and four pursuit squadrons, representing a wing formation for each type of machine.

The effects of this will be to give the Air Service definite recognition as the fourth arm of the line, or combat forces of the Army, the others being infantry, cavalry and artillery. All other units are supplemental forces, generally known as auxiliary arms or staff corps troops.

Storage capacity has been provided for approximately 6,000 complete 'planes, not including those in service or in immediate reserve with the squadrons. In addition airplane motors by the thousand have been stored, the upkeep of any unit in service requiring three or four extra motors a 'plane.

To make this plan effective will require the purchase by the Government of several thousand airplanes of types which the Air Service does not at present own. Bombing 'planes, single-seater fighters and two-seater fighters will be required.

The present DH-4 will have to be remodeled to bring it up to date for observation and photographic work. Advanced training types will also probably be needed.

To secure the above equipment will require no new legislation for there are funds available from present appropriations to cover the cost of the new machines.

Paris Air Conference

The Aeronautical Commission of the Peace Conference held a meeting in Paris, March 31, to receive and consider reports from sub-committees concerning military, legal, commercial and technical subjects. It was found that the sub-committees had not completed their work, but the commission approved the temporary reports submitted.

It was agreed to put before the Supreme Council the proposals to be finally submitted at the next meeting by the joint military and legal sub-committee. Good progress has been reached on important points in connection with the future of commercial aviation.

At the next meeting of the Commission it is expected that the general principles and much of the detail of the inter-Allied Aerial Convention may be settled finally.

New York Police Air Force

The New York Police Department has taken active steps to form an aviation section of the Police Reserves under Deputy Commissioner Rodman Wanamaker. Col. Jefferson De Mont Thompson is in command of the air force.

The following fliers have been sworn into the service: Lieut. Paul Micelli, Edward L. Smith, James R. McCaffrey, Capt. S. Herbert Mapes, Lieut. Leigh J. Bair, Capt. Hugo Sunstedt, Capt. Joseph C. Stehlin, Lieut. Edmund C. Rowan, Lieut. John Robertson Hoyt, Lieut. Frank Sefern Ennis, Miles F. Kellin, Ensign Albert Pendleton Taliaferro, Jr., Ensign Frank E. Hutcheon, Charles Siems, Ensign J. G. Stewart, Charles S. Jones, and Lieut. Hilbert L. Bair.

New Parachute Tested

According to the *Kelly Field Eagle*, a new type of parachute, which is the invention of First Lieut. Solomon L. Van Meter, A. S., has successfully been tested at Wilbur Wright Field.

Lieut. Van Meter's invention is said to mark a great advance upon the old system of jumping from the plane with the parachute packed on the back of the pilot. The old method was unsatisfactory because the pilot would often experience difficulty in clearing the ship, and the parachute would become entangled in the tail of the ship, especially in the case of a tailspin. It was also unsafe to jump by the old way from a height of less than several hundred feet, as the parachute often fell that far before opening.

The Van Meter parachute overcomes these drawbacks in the following manner: The parachute, which is enclosed within an aluminum container, is placed in the airplane body directly behind the rear cockpit. Under the container is a powerful spring, which, when released throws the parachute a distance of at least twenty feet from the ship, at which time the parachute immediately opens and draws the pilot from the ship. At the same time the pilot releases the spring which discharges the aluminum cartridge, the pilot himself is automatically released from his seat.

When he is released, the seat falls back a short distance against a slideway and makes his departure from the ship less abrupt. The spring is easily released by pulling a ring fastened on either side of the pilot's seat.

Further experiments will be conducted at McCook Field, Lieutenant Van Meter having been assigned to duty in this connection with the Aircraft Engineering Department.

Atlantic City Air Meet

At the Second Pan-American Aeronautic Convention to be held at Atlantic City in May many prizes will be competed for and several noted fliers have indicated their intention of participating in the contests.

Col. William A. Bishop has offered a trophy to be known as the Ace of Aces trophy, to be awarded in 1919 to the flier who makes the best speed between Toronto and Atlantic City.

The Atlantic City Aero Club has offered $10,000 to the pilot who begins or ends a transatlantic flight at Atlantic City during the month of May.

The Valentine prizes for seaplanes amount to $1850 and are to go to the pilot who makes the greatest number of laps between Atlantic City and Cape May Naval Air Station during the convention.

Glenn H. Curtiss has offered a $1000 prize to the first pilot who flies 1000 miles without stopping in contests for the Curtiss Marine Flying Trophy.

Speed prizes for seaplanes to be competed for on May 30 amount to $1750.

Many medals are offered for various special events and $2000 is offered for the winner of intercollegiate contests.

Service Association Moves

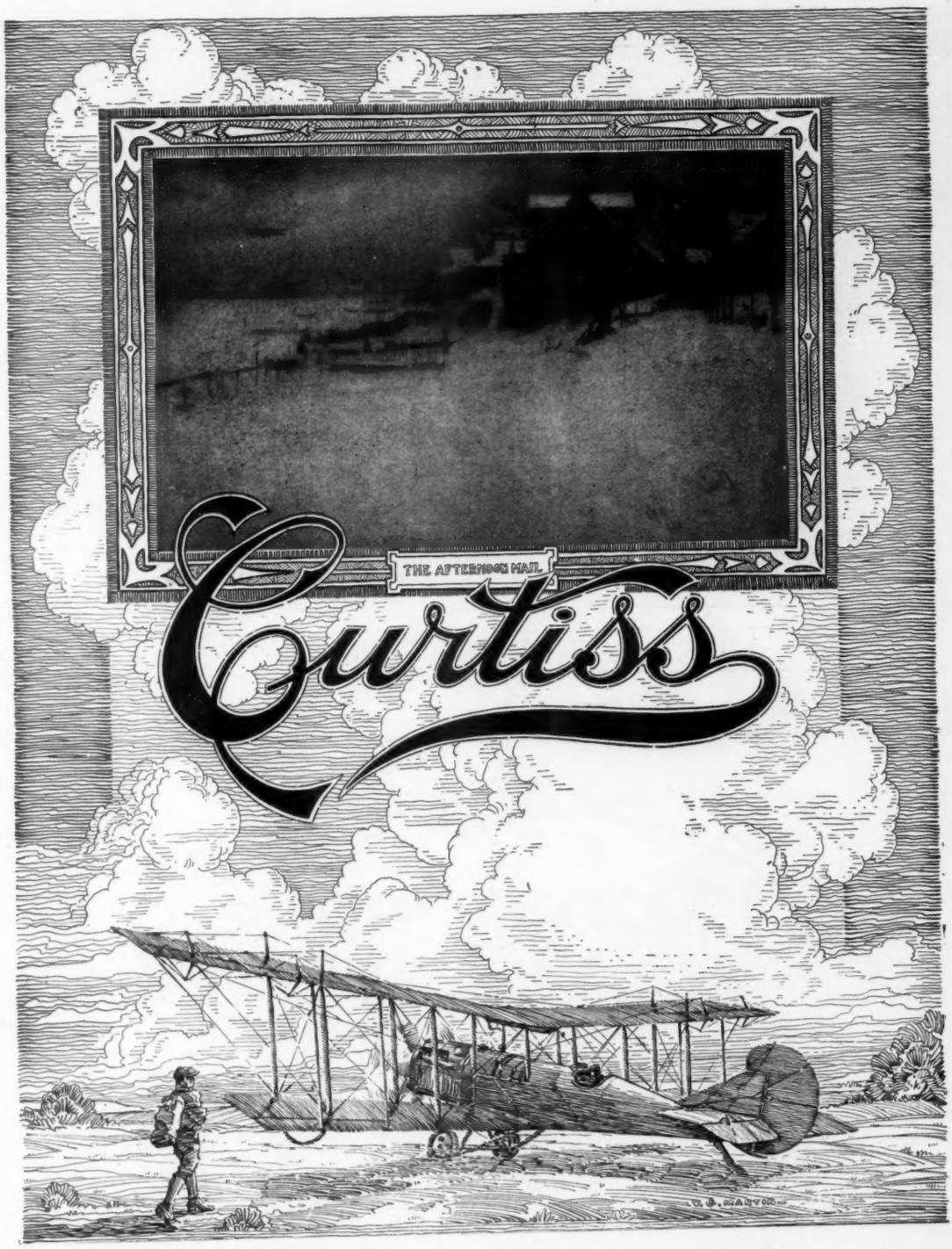
The publication office of U. S. Air Service and the office of the Army and Navy Air Service Association have been moved from Building D, 6th and B Streets, Washington, D. C., to Room 645 Munsey Bldg., Washington, D. C.

This new location will be a convenience to the business interests of the association and particularly the magazine. Members of the association, as well as prospective members, will be welcomed when in Washington.

The secretary, Capt. Earl N. Findley, A. S. A., and Lieutenants Meade and Metcalf, who have been detailed as members of the magazine staff, are now located in the new offices.

E. Stinson Buys Sport Airplane

The first reported sale of a small sporting airplane for exhibition work was recently made by the Aircraft Engineering Corp. of New York, when they sold one of their ACE models to Aviator Eddie Stinson, of the famous Stinson family of fliers. Before purchasing the plane Stinson put the small machine through all the stunts for which he is famous. He will use it during the summer for exhibition work.



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AIRMAN BRINGS MAIL IN BLINDING SQUALL

Special to The New York Times

WASHINGTON, March 28.—A Curtiss, piloted by John N. Miller, a former naval aviator, made the trip from Philadelphia to New York this afternoon despite the heavy gale which swept the Atlantic seaboard and delivered its cargo.

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CURTISS AEROPLANE AND MOTOR CORPORATION, *Sales Office:* 52 VANDERBILT AVE., NEW YORK CITY

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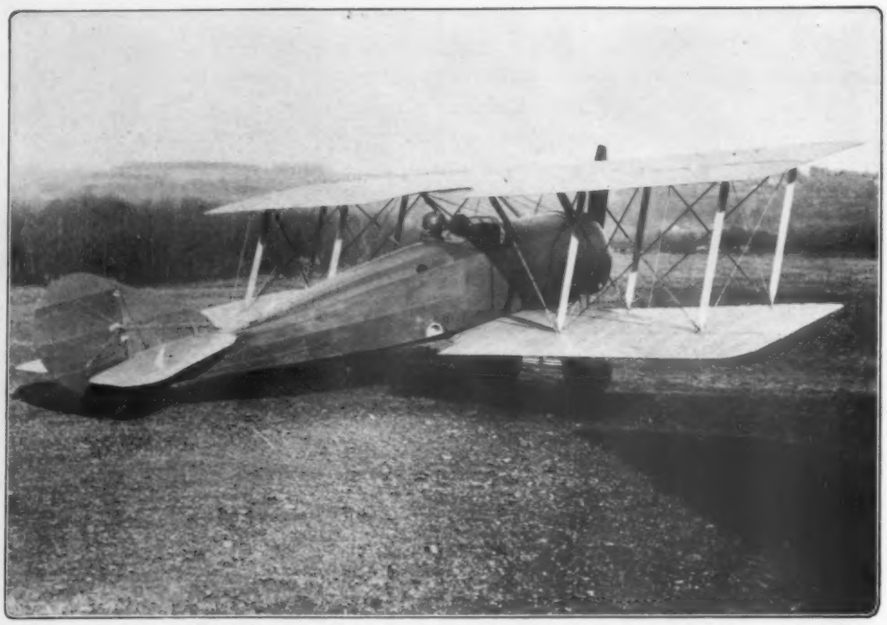

THOMAS-MORSE

Side-by-Side Seater, Type S-7

Equipped with 80 h. p. Le Rhone Engine.

High speed, 90 M. P. H.

Landing speed, 35 M. P. H.

Climb 6,700 ft. in first ten minutes.

THOMAS-MORSE AIRCRAFT CORPORATION

ITHACA, N.Y. U.S.A.

Beardmore

Aero Engines

The Supremacy of "Beardmore" is beyond dispute.

¶ The late Col. Cody on his bi-plane beat all comers, both British and Foreign, the Engine used was Beardmore design. SIMILAR ENGINES BUILT PRE-WAR DAYS ARE STILL IN ACTIVE SERVICE.

¶ During the past four years of hostilities, Beardmore Engines have been in constant use on all fronts. Any member of the R. A. F. will testify to Beardmore quality, efficiency and reliability.

¶ Beardmore Six Cylinder, Vertical, 120 and 160 H. P. Engines are Engines of experience and for commercial work will prove the best investment.

Inquiries solicited regarding U. S. A. and Canadian representation

THE BEARDMORE AERO ENGINE, LIMITED

London Showrooms and Depot — 112 Great Portland Street, London, W. 1

FAME

CDC

TO
RETIRED SERVICE FLIERS
with apologies to
"WALT MASON"
of the N. Y. Evening Globe.

You played your part and did your share,—p'raps over here, p'raps over there—and hate like smoke to quit the game and life, somehow, don't seem the same. You hung around the dear old ship, and said "Good Bye" with quiv'ring lip and now its back to bench or chair (Gosh! it was good, away UP THERE),—and now you're grouchy, sore and glum and think the world's gone on the bum. Cheer up, old tops, it ain't so bad for there's good news to make you glad and comes from North, South, East and West,—of all good news it's far the best. BELLANCA'S 'BUS has shown how soon the flying game is timed to boom; ere long the skies will tell the tale how sky-high enterprise can't fail, —with you at work with work galore (all you can do and then some more). 'Twould take too long to tell it here, but just to prove the news' sincere, just sit down now and write a line, address it "No. two nine nine," and say just what you'd like to do and see if wishes can't come true!

The Sign of

MARYLAND PRESSED STEEL CO (AIRCRAFT DEPARTMENT) "BELLANCA" TRADE MARK HAGERSTOWN MARYLAND U.S.A. AIRCRAFT

The AEROPLANE FOR THE AVERAGE MAN

For Specifications and Fullest Information:
HARRY E. TUDOR
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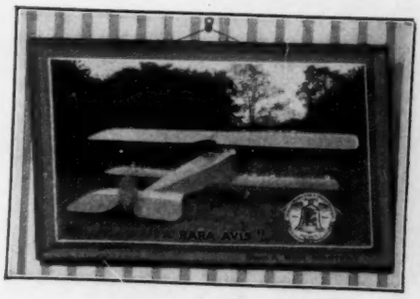
SAFETY! ECONOMY!! EFFICIENCY!!!

and a picture to look at



THE
BELLANCA
55 H.P. ANZANI
TWO-SEATER
BIPLANE

Price Complete $3,500 F.O.B.

a counterbalanced aviation crankshaft . . . .

Patented July 10th, 1917

one of the 18 different
models we are now making
for 14 aviation motor companies . . .
reduces vibration and eliminates bearing pressure

We have shipped 46,637 Aviation Crankshafts to January 16, 1919

THE PARK DROP FORGE CO. CLEVELAND, OHIO

ACKERMAN
LANDING
GEAR
Is the latest and highest development in the construction of Landing Gear
Their
SIMPLICITY
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make them the logical equipment for the Modern Airplane.
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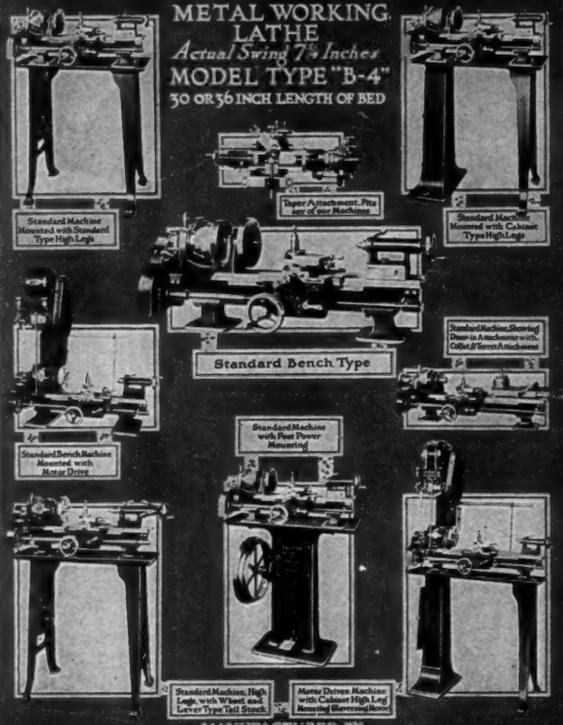

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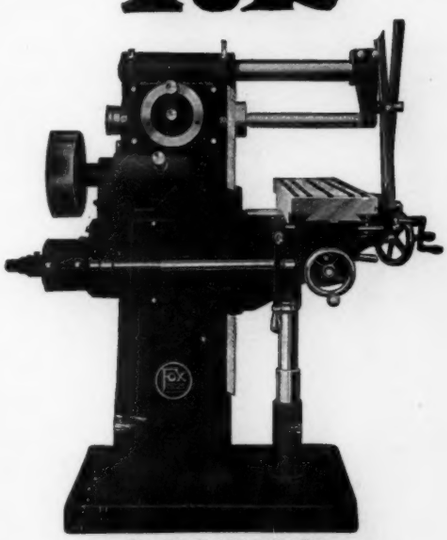

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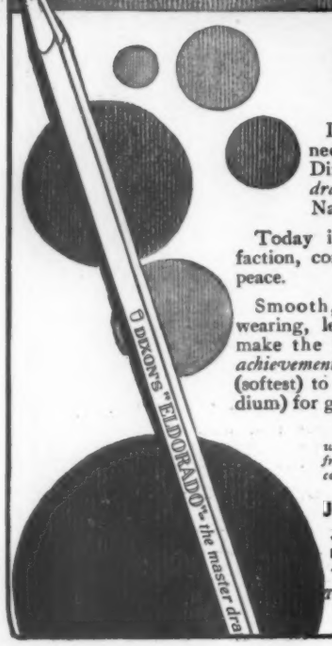

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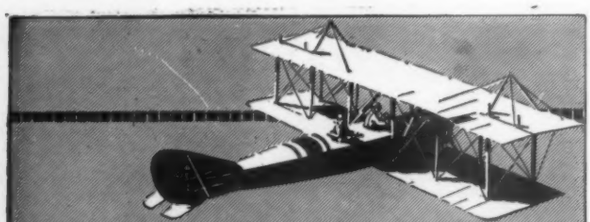

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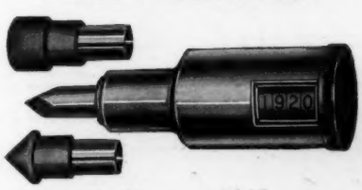

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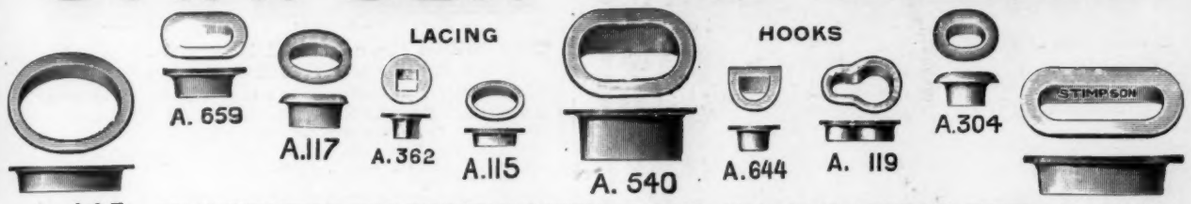

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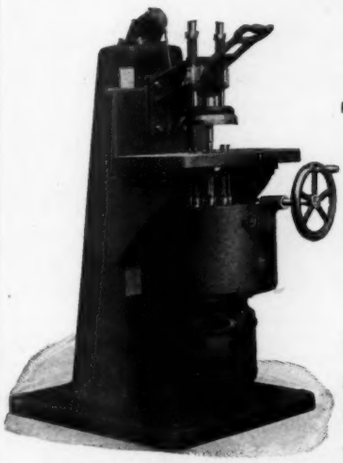

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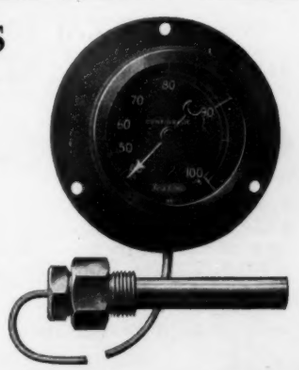

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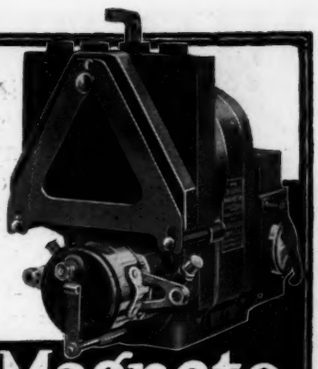

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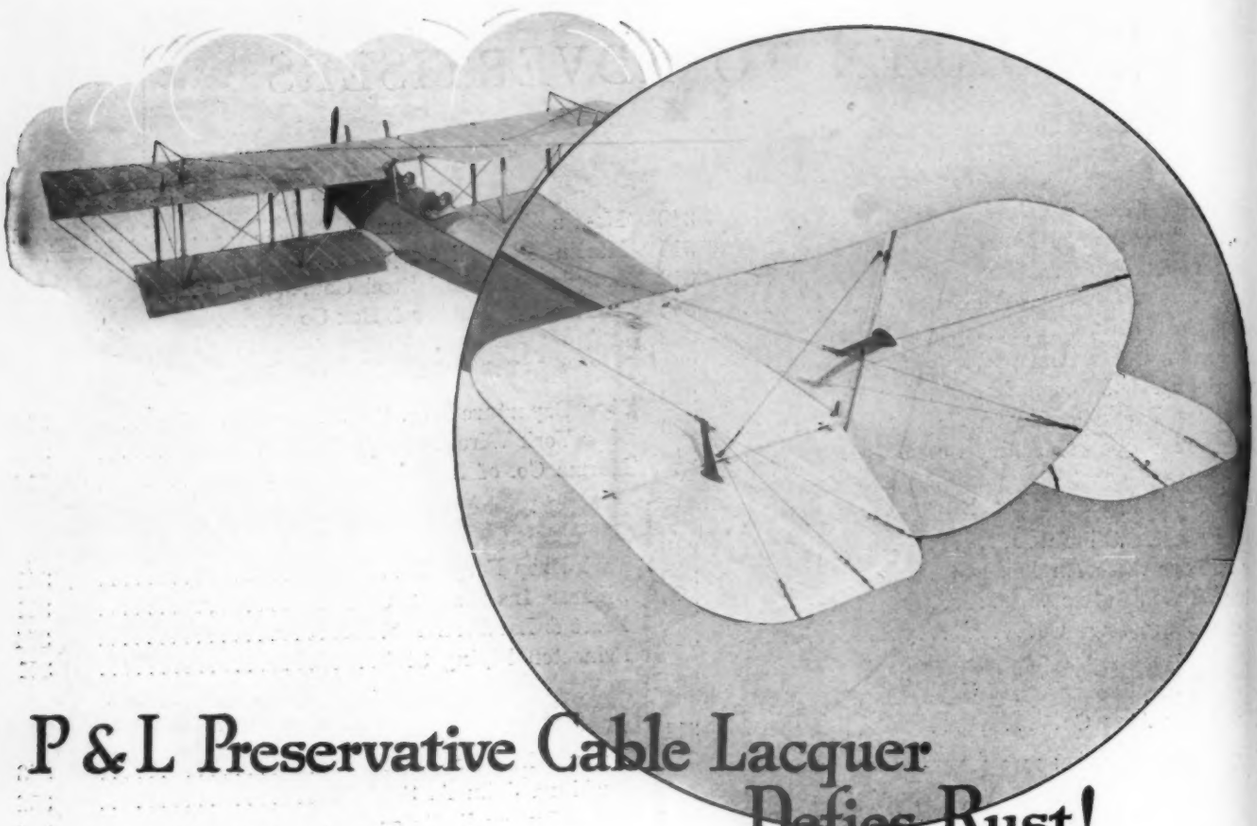

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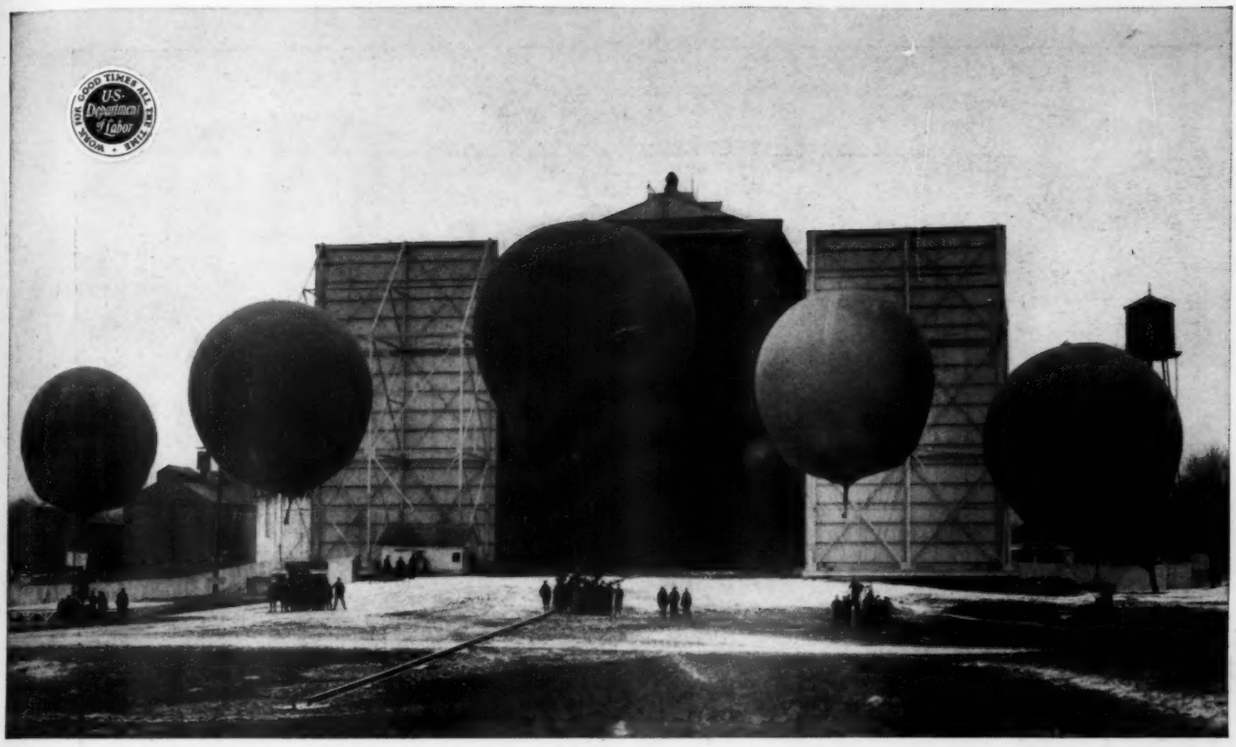
FACTORIES

NEW YORK BUFFALO CHICAGO

BRIDGEBURG, ONTARIO



Merely the Fore-Runners

The eight hundred full-size balloons that The Goodyear Tire & Rubber Company has manufactured during the last nine years can only be regarded as the fore-runners of third dimension transport.

Just as the early spherical balloons have been succeeded by larger and more practical types, so will the dirigibles of today be merely modest precedents for tomorrow.

We are confident that the day is not far distant when passenger travel by air will be an established reality—established on a commercial basis as one of the necessary forms of modern transportation.

We are prepared for the great future.

For nine years The Goodyear Tire & Rubber Company has been the leading manufacturer of rubberized balloon fabric in America.

This supremacy has naturally led to pioneering the development of craft lighter than air.

It has produced a body of Goodyear workmen who are truly balloon craftsmen.

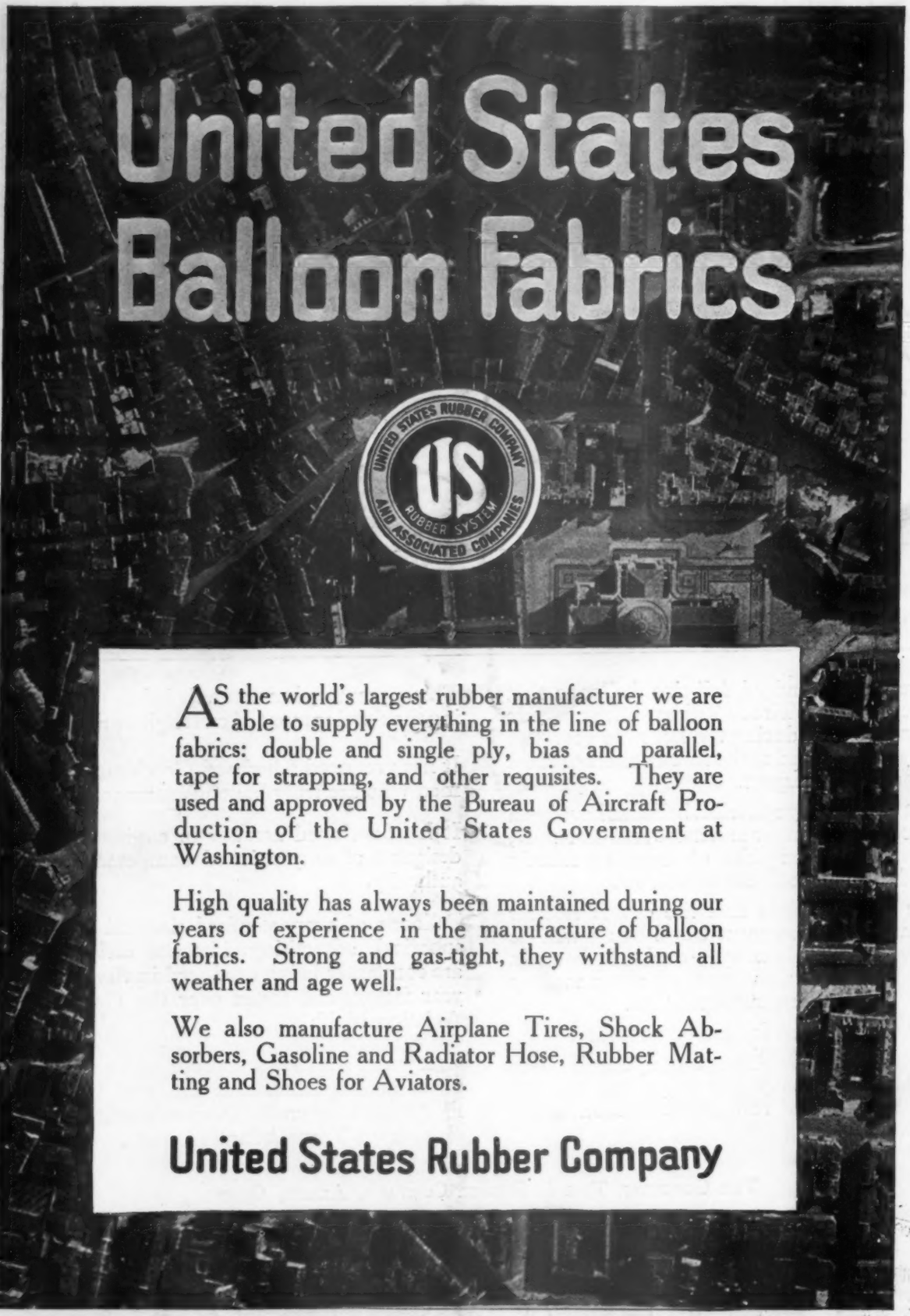
It has developed aeronautic engineers and designers of unquestioned competence and authority.

Balloons of every standard size and type—spherical, advertising, kite and dirigible—are constantly being produced in the Goodyear factory and tested over the Goodyear Aviation Field.

On special sizes we are prepared to submit plans and specifications for any type of lighter-than-air craft—from miniature models to huge Trans-Atlantic Liners.

THE GOODYEAR TIRE & RUBBER COMPANY, AKRON, OHIO

GOODYEAR
AKRON



AS the world's largest rubber manufacturer we are able to supply everything in the line of balloon fabrics: double and single ply, bias and parallel, tape for strapping, and other requisites. They are used and approved by the Bureau of Aircraft Production of the United States Government at Washington.

High quality has always been maintained during our years of experience in the manufacture of balloon fabrics. Strong and gas-tight, they withstand all weather and age well.

We also manufacture Airplane Tires, Shock Absorbers, Gasoline and Radiator Hose, Rubber Matting and Shoes for Aviators.

United States Rubber Company

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